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ORIGINAL ARTICLES.

I.—On a Head of *Eurycormus* from the Kimmeridge Clay of Ely.[1]

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(PLATE X. Figs. 1–8.)

LITTLE is known of the Upper Jurassic Fish-fauna from discoveries in British Formations; and though considerable information upon the subject has already been acquired, this has been chiefly obtained from the fine Lithographic Stones of Bavaria, Würtemberg, and France. In these deposits, as is well known, fish-skeletons are found in an almost complete state, with the bones remarkably well preserved; and the only obstacle to the satisfactory determination of the various elements is the extreme compression to which the fossils have been subjected and the hardness of the matrix in which they are enveloped.

Within the last few years, remains of similar fishes have been met with in several localities in the Oxford and Kimmeridge Clays of England; and the soft character of the rock often allows of these fossils being completely disengaged from matrix. Such specimens are of extreme value for the precise determination of certain skeletal features in the genera to which they belong; and it is the object of the present paper to describe an example of *Eurycormus* elucidating some new points in the skeletal anatomy of this genus. The specimen has already been briefly noticed[2] as being the first evidence of the occurrence of the fish in the British Jurassic.

The fossil in question (Pl. X. Figs. 1–8) is a fine example of the skull and adjoining elements discovered by Mr. Henry Keeping in the Kimmeridge Clay of Ely, and makes known, for the first time, the form and proportions of several of the head-bones in *Eurycormus*. The specimen was acquired last year by the Woodwardian Museum, Cambridge, and the writer is indebted to the kindness of Professor McKenny Hughes for the opportunity of investigating its characters.

The occipital border (Fig. 2) forms a straight transverse line, and the width of the cranium at this point is nearly equal to half of its total length. The occipital bones are too much crushed and obscured for

[1] Read before the Geological Society, January 8th, 1890.

[2] Smith Woodward, "Preliminary Notes on some New and Little-known British Jurassic Fishes," Rep. Brit. Assoc., 1889, and Geol. Mag. [3] Vol. VI. (1889), p. 448.

description; the side walls of the brain-case and the otic capsule, though evidently ossified, are also obscure; a small post-frontal (Fig. 1, *pt. f.*) seems to be present; and the only other recognizable cartilage-bone worthy of note is the robust, triangular prefrontal (Fig. 1, *pr. f.*), which constitutes the antero-superior angle of the orbit. The interorbital septum is apparently unossified.

The membrane bones of the cranial roof are much crushed and broken, but portions of the long, narrow parietals (Figs. 1, 2, *pa.*) and frontals (Fig. 1, *f.*) are distinguishable, the former and the posterior half of the latter displaying a superficial tubercular ornament. The parietals extend to the occipital border, and the hinder part of their median suture exhibits a very deep sinuosity (Fig. 2). The precise limits of the parietals and frontals are not shown, owing to the accidental crushing and removal of the middle region of the skull. On either side of the parietals, a large squamosal occurs (Figs. 1, 2, *sq.*), longer than broad, and with a slightly excavated outer border into which fits the upper margin of the superior post-orbital: it is superficially marked by a few scattered tubercles and pittings, and a transverse, though inwardly and backwardly inclined groove in the posterior half seems to indicate a sensory canal. On the right side, partly overlapping the anterior extremity of the frontal, is a well-preserved nasal (Fig. 1, *na.*, Fig. 3), longer than broad, with a rounded and somewhat fluted posterior margin, and superficially marked with a few rugosities and tuberculations: at the anterior outer angle of this bone a small narrow smooth process occurs, distinctly notched at its base, especially on the inner side, and thus marking the position of the openings of the olfactory capsule.

The hyomandibular (Fig. 4) is exposed on the left side, much vertically elongated, and with a broad mesial expansion posteriorly; the upper extremity is scarcely expanded, the anterior margin is slightly concave, and a prominent longitudinal ridge occurs upon the anterior half of the outer face of the bone, gradually becoming obliterated above and below. Of the symplectic and quadrate nothing is recognizable, and the only element of the pterygo-palatine arcade identifiable with certainty appears to be a portion of the great, broad metapterygoid on the left side.

The extremity of the snout is broken away, thus exposing small plate-like bones in the anterior part of the roof of the mouth, covered with a cluster of slender, conical teeth (Fig. 8): these are evidently the vomers, and may perhaps also comprise portions of the palatines. The premaxillæ are lost, except a small fragment on the left side, which bears a conical tooth of larger size than those of the inner cluster just mentioned. The maxilla (Fig. 1, *mx.*) is long and slender, laterally compressed, gently arched so that the alveolar margin is convex, and more than twice as deep behind as in front; a robust inwardly-directed process extends from the anterior end of the bone to abut against a portion either of the palatine or vomer; its outer face is rugose, but not tuberculated; and the teeth are arranged in a single close series. In the hinder two-thirds of its length the maxilla is bounded above by a long narrow jugal bone (Fig. 1, *ju.*), abruptly

truncated behind but rapidly tapering to a point in front, and with a smooth or only slightly rugose external surface.

The mandible is much crushed and the symphysis lost, but three of the elements are readily distinguishable. A thin, plate-like splenial (Fig. 5, *spl.*) occupies the inner face, and is provided with small teeth. The dentary (Figs. 1, 5, *d.*) is the largest bone and only shows the sockets of a single series of relatively large teeth in the anterior portion of its length: it is relatively deep and seems to have been somewhat bent inwards inferiorly. The hinder border of the dentary exhibits a re-entering angle into which fits the anterior pointed extremity of the well-developed angular bone (Fig. 1, *ag.*); this element being longer than deep, with a thickened, smooth, ginglymoid hinder face (Fig. 6), probably for articulation with the inferior extremity of the preoperculum.

The teeth in both jaws are round in section, relatively long and slender, and may be appropriately described as styliform.

The membrane bones of the cheek are very large and few in number. A single trapezoidal bone, narrower above than below, occupies the greater part of the postorbital region (Fig. 1, *pt.o*$_1$.); two (or perhaps three) smaller postorbitals bound its inferior margin (*pt.o.* $_{2, 3}$); and there is a trace possibly of a small triangular element at the hinder end of the maxilla and jugal (*x*). A narrow suborbital bar (*so.*), without distinct sutures, extends along the superior borders of the jugal to a single, large ovoid plate (*ao.*), which occupies the space between the cranial margin and the anterior third of the maxilla. These bones are externally ornamented in part by rugosities, in part by tuberculations.

The sclerotic is ossified, and fragments are seen on the right side (Fig. 1, *scler.*).

The single azygous jugular plate is very large, elongated, and narrow, about two-thirds as long as the mandible; and immediately behind it are the remains of a few stout, narrow branchiostegal rays, on the right side overlapping a fragment of the ceratohyal. The preoperculum is shown on the right side in position (Fig. 1, *p.op.*), very long and narrow and gently arched; and immediately behind is the large, quadrate operculum (*op.*). The suboperculum and interoperculum are unfortunately destroyed, but a fragment of the former is seen on the left side.

A large triangular supratemporal bone (Fig. 1, *st.*) occurs above the operculum, tapering towards its apex at the middle of the occiput. A small supraclavicle (*s. cl.*) and the upper half of the clavicle (*cl.*) are also recognizable.

The vertebræ of *Eurycormus* have already been described by Dr. von Zittel,[1] and it thus suffices merely to note that two examples of the characteristic form (Fig. 7) are seen in the hinder portion of the fossil. The pleurocentra (*pl.*) and hypocentra (*hyp.*) are distinctly separated by the oblique lateral suture; and the inferior element bears a lateral articular facette for a bone of the hæmal arch.

[1] K. A. von Zittel, "Handbuch der Palaeontologie" (1887), p. 230, fig. 242.

On comparing the head of *Eurycormus*, as now described, with that of the recent *Amia*,[1] there will be found to exist the most remarkable similarity, not only in general features, but even in points of detail. The membrane bones are all similar in form and arrangement, and the majority differ little in relative proportions; the dentition is identical; and even in so special and unusual a feature as the direct articulation of the preoperculum with the angular bone the two genera under comparison exactly agree. The genus *Eurycormus* has already been placed in taxonomic works in the same great group as the existing *Amia*; and the new osteological facts detailed above thus tend to confirm the accepted determination.

II.—Note on the Gill-rakers of *Leedsia problematica*—a Gigantic Fish from the Oxford Clay.

By A. Smith Woodward, F.G.S., F.Z.S.

(PLATE X. Figs. 9, 10.)

At the last meeting of the British Association the writer briefly described a remarkable series of bones of a large unknown fish from the Oxford Clay of Peterborough, preserved in the collection of Mr. Alfred N. Leeds, of Eyebury. The name of *Leedsichthys problematicus* was proposed for the genus and species thus indicated; and the systematic position of the fish remained doubtful, owing to the fragmentary character of its skeleton.[2]

No further discoveries of importance have hitherto been made, but an opportunity is now afforded of publishing figures of two imperfect gill-rakers (Pl. X. Figs. 9, 10, 10*a*), which are perhaps the most readily recognized and characteristic elements of the fish in question. As shown in side-view (Figs. 9, 10), each gill-raker is laterally compressed, slightly expanded at the basal extremity, and rarely straight, but irregularly bent or contorted. The surface is coarsely rugose, and one long border is rounded, while the other is cleft by a longitudinal median furrow. The rounded border is comparatively smooth, but the furrowed edge (Fig. 10*a*) is coarsely serrated, a series of short oblique ridges terminating in points on each side.

It has been suggested that the generic name may be conveniently shortened, that of *Leedsia* not being elsewhere occupied. The writer hence proposes to refer to the fish in future as *Leedsia problematica*.

EXPLANATION OF PLATE X.

Fig. 1. *Eurycormus grandis*, A. S. Woodw.; head, lateral aspect, two-thirds nat. size. Kimmeridge Clay, Ely. [Woodwardian Museum, Cambridge.] *ag.* angular. *ao.* antorbital. *cl.* clavicle. *d.* dentary. *f.* frontal. *ju.* jugal. *na.* nasal. *op.* operculum. *p.op.* preoperculum. *pa.* parietal. *pr.f.* prefrontal. *pt.f.* postfrontal. *pt.o* 1-3. postorbitals. *s.cl.* supraclavicle. *scler.* sclerotic. *so.* suborbital. *sq.* squamosal. *st.* supratemporal. *x.* doubtful bone.

„ 2. ——— hinder portion of cranium, superior aspect.

[1] R. W. Shufeldt, "The Osteology of *Amia calva*," Rep. U.S. Fish Commission, 1883, pp. 747–837, with plates.

[2] Geol. Mag. [3] Vol. VI. (1889), pp. 451–453.

Fig. 3. *Eurycormus grandis*, right nasal bone, outer aspect.
„ 4. ——— left hyomandibular, outer lateral aspect.
„ 5. ——— anterior section of mandibular ramus. *d.* dentary. *spl.* splenial.
„ 6. ——— posterior end-view of right mandibular ramus, showing gingly-moid surface.
„ 7. ——— two anterior vertebræ, lateral aspect. *hyp.* hypocentrum. *pl.* pleurocentrum.
„ 8. ——— front view of dentition of vomers (? and palatines).
„ 9, 10. *Leedsia problematica*, A. S. Woodw.; imperfect gill-rakers, side view. Oxford Clay, Peterborough. [Collection of Alfred N. Leeds, Esq., Eyebury.]
10*a*. edge view of part of Fig. 10.
Unless otherwise stated, the Figures are of the natural size.

III.—Notes on the Geology of Finland.

By R. N. Lucas, B.A.

A STAY in Finland of some months' duration (in the summer of 1885) enabled me to make an acquaintance of considerable intimacy with the Archæan rocks of that very interesting district.

Owing to the kindness of two prominent members of the Finnish Geological Survey, Prof. Wiik, who was good enough to place the valuable collections of the Helsingfors University Museum at my disposal, and was constantly ready to give me assistance in every way, and the Hon. A. F. Tigerstedt, with whom I traversed some hundreds of miles of country, I succeeded in amassing a considerable number of observations, which it was at one time my intention to collect together under the above heading. Since forming this intention, however, I had the good fortune to receive the later sheets of the official survey with the accompanying descriptions. I felt that the observations of an individual could in no case possess the value that attaches to an official work of this kind, and I have therefore abandoned my original design. The plan adopted in the following pages has been to replace the observations recorded in my note-book by details drawn from the sheets of the survey. My own observations have merely dictated the general plan, have formed in fact the mould into which the disconnected data drawn from the above-mentioned sources have been poured. Those data themselves have in the main been selected from the survey sheets, and may therefore be regarded as possessing a semi-official stamp.

An attempt has been made to introduce some uniformity into the nomenclature adopted. Thus "gneissoid granite," "granitoid gneiss," "granitoidite," etc., have been replaced by granite-gneiss and gneiss-granite respectively,—terms to which, as will be seen in the sequel, a very *definite* signification is attached; and the confusing term "hälleflinta" has been relegated to that capacious limbo which has already received the "greenstones" and "traps."

I. The Archæan Series.

The architectonic relationships of the fundamental rocks of the country, though extremely complicated when viewed in detail, present when considered *en masse* some general characteristics which may be of use in assisting the reader to comprehend the structure of the region as a whole.

The central lake district, comprised roughly speaking by a polygon drawn through the points Heinola, Tammerfors, Jyvaskylä, Kuopio, and St. Michel, is mainly of eruptive origin, consisting of granites, syenites, etc., of Laurentian age that have pushed their way through the gneisses and schists that surround them, and are very likely to some extent responsible for the tremendous crushing and crumpling which the latter have undergone. The "rapakivi" district of the extreme south, which will be described fully in the sequel, may be regarded as in some sort a continuation of this eruptive area. Round this region are arranged the foliated members of the Archæan series, contorted, folded, reduplicated and turned upside down to any extent, but still in the main striking with considerable regularity, on the west side, N.—S. or N.E.—S.W.; on the east side N.W.—S.E.; and on the south side E.—W. On proceeding to walk outwards, therefore, from this central granitic district, one would successively cross the edges of the Laurentian series, meeting first with the granite-gneiss and then with the younger gneisses and schists, though the exact order in which one would encounter the various members is often confused and inverted by folding or reduplication. In the more eastern districts, Karelen and the country north of Ladoga Lake, one would eventually meet the Huronian, and, further east still, the Taconian series. Of course it is not intended to be understood by this that the eruptive rocks are confined to the districts above indicated, the whole of all these series being much pierced by both acid and basic intrusive rocks, but merely that within this region eruptive rocks predominate. It will thus be seen that the geotectonic structure of Finland is not unlike that of Switzerland during the Triassic period—a low Archæan district—composed centrally in the main of granite and allied rocks, towards its outskirts of gneisses and schists, which are overlain by rocks of comparatively recent geological age. Should Finland ever be raised into a great mountain-chain, which, as the country has for a long time been continually rising, may some day be brought to pass, this central granite area, then enormously compressed, would probably take upon it exactly the appearance and characteristics of the protogene granite of the Central Alps, and the gneisses and other members of crystalline and sedimentary series would be found occupying corresponding situations.

The district to which the following notes principally refer lies to the south of this central granitic region, and comprises consequently the older members of the Archæan series.

It is proposed to divide the subject into two parts, dealing with—I. Foliated and Crystalline Rocks. II. Eruptive Rocks.

Foliated Rocks.

Granite-Gneiss.[1]—This is the name now generally adopted by the Finnish geologists for the lowest and consequently the most

[1] Though placed under the heading "Foliated Rocks" granite-gneiss should more properly be described as "banded."

ancient member of the Archæan series. Wherever it is exposed to view it appears as emerging from beneath younger Laurentian strata which have been deposited directly upon it, or it is covered as far as can be seen conformably by the younger micaceous gneiss into which it passes by insensible degrees. Thus in the neighbourhood of Pääjärvi it is overlain for a considerable distance by hornblende gneiss and eurite, from which it is sharply separated. As a rule it is much pierced by intrusive granite of probably similar age, which has found its way in between the layers of the granite-gneiss, and which, having taken on a parallelism of structure through the influence of lateral pressure, is often on superficial examination hardly to be distinguished from it, and has then received the name of gneiss-granite. The mineralogical composition of granite-gneiss is as a rule extremely uniform, consisting in varying proportions of light grey and grey fatty-looking orthoclase, and white pearly oligoclase, very finely striated grey to white transparent and semi-transparent quartz and black mica. At times a certain amount of red orthoclase mingles with these constituents, causing the rock to assume a reddish colour, and in the neighbourhood of the above-mentioned granite masses it passes over completely into the red oligoclase gneiss-granite.

Microscopic sections of the granite-gneiss of Southern Finland, kindly placed by Prof. Wiik at my disposal during my stay in Helsingfors, were found to display with marked distinctness the peculiarities of granite-gneiss that distinguish it both from ordinary granite and from gneiss-granite. The crystals of quartz and felspar, particularly of the former, are seldom completely developed, but present a rounded appearance, suggestive of crystalline aggregation about originally attrited grains, in this respect resembling strongly the appearance under the microscope of the more crystalline Devonian "grauwackes." The crystals of mica are usually well developed, and do not in any way present peculiarities similar to those of the felspar and quartz crystals. They occasionally give evidence of internal movements within the rock, being broken across, and one or more of the fragments being transported a short distance in a direction parallel to the general banding; but there are no long streams of mica microliths, as is observed in sheared granites, and the quartz and felspar crystals fill in without interruption the space between the mica fragments. This would seem to point to the movements in question having originated during a pasty or semi-pasty condition of the rock, rather than to effects of pressure or shearing stress in a rock perfectly hard and crystalline at the time.

Grey Gneiss.—The grey micaceous gneiss, which forms the next higher member of the series, overlies the older granite-gneiss into which it often gradually passes, as in the neighbourhood of Borgnäs. It has the same general strike as the gneiss-granite, that is to say, roughly speaking, E. and W., though both at times deviate a good deal from this general rule. In its normal condition it consists of black mica, generally white felspar and quartz. It is frequently much cut up and pierced by veins of granite, as for instance in the

neighbourhood of Vihtjärvi, where it is so much impregnated with calcite as to effervesce when treated with acid. Not far from Valkjärvi Lake it is bordered by hornblende schists, when it becomes very rich in hornblende, and often contains magnetic iron ore. At times it passes into a fine-grained, dark grey rock resembling a felsitic schist, and occasionally it becomes very micaceous and contains chlorite. Granite veins and dykes often penetrate it to a very great extent, the granite running through the gneiss, the gneiss interbedded with and surrounded by granite; and sometimes large fragments of gneiss have been broken off and enveloped in the eruptive rock, as in the district around Borgo and near Mansikiri, to such a degree that it becomes almost impossible to say whether the rock should be described as granite or gneiss.

A red variety of micaceous gneiss occurs at a few spots, as for instance near Mörskom, where it strikes E. to W., and is very fine-grained, becoming at times euritic, and consists of reddish-brown orthoclase, yellowish-red plagioclase, grey and white quartz and green mica.

Both varieties of micaceous gneiss are at times very rich in garnet, which mineral tends to replace the mica, and they then become red and white garnet-gneiss, as at Nurmijärvi and Koskis, which at times (as near Loji) growing finer in structure passes into garnet-mica-schist.

A graphite-gneiss has also been observed cutting in a narrow band through a hill of granite near Kukilu church.

In contact with granite the gneiss presents a series of phenomena interesting in their irregularity. In some cases it runs along the surface of contact without any indications of being affected by the contiguity of the eruptive rock. At other times, though there is nothing of the nature of transition from one rock to the other, and the line of separation is sharply defined, the gneiss in proximity to the granite becomes much distorted, and then generally appears of finer grain. Often large portions are broken off and imbedded in the granite, and the foliation of these detached portions is then much contorted. This occurs notably in Sibbo Bay on the south coast. A peculiar facies, which is doubtless a contact phenomenon, occurs occasionally in which the felspar individuals are much larger and coarser, and the whole mass becomes porphyritic.

These varying phenomena may in all probability be best explained by the supposition that the gneiss was in some instances deposited directly upon solidified granite, in others it has been subjected to the modifying effects, both mechanical, physical, and chemical, of a lengthened contact with masses of granite in a state of fusion. That this latter state of things prevailed over extensive areas and for a considerable length of time is rendered probable, not only by the phenomena of disruption and contortion caused by the intrusive action of the granite alluded to above, but also by the gradual passage of *grey gneiss into gneiss-granite* not unfrequently observed, as at Nackskog.

Microscopic examination has occasionally brought to light the

occurrence of magnesia, mica, and microline (in specimens from Horis and Sukkola).

Hornblende-Gneiss and Eurite.—These rocks, which together form the principal member of the Upper Laurentian series, occur almost always together, alternating with and passing into one another to such an extent as to necessitate their being considered in conjunction. They thus form one stratified system, and occur as in the neighbourhood of Koskis and Hattina, on either side of belts of granite-gneiss, which they overlie, and presumably in some places cover; their strike being almost always parallel to that of the latter formation. All the members of this series, whether containing hornblende or not, present a more or less fine-grained appearance, and the bands of micaceous gneiss which are at times interbedded approach very closely to the structure of eurite, and might appropriately be termed eurite-gneiss. Mineralogically the composition of this latter rock is the same as that of ordinary gneiss, white orthoclase and oligoclase in small, weathered grains with black mica in small shining laminæ, and small white transparent grains of quartz. At times the grain is so close that the rock becomes a true eurite, the separate minerals composing which are only visible under the microscope. It always contains some hornblende, and passes, as the amount of that mineral increases, into a perfect hornblende-gneiss or hornblende-eurite, as the case may be. Iron and arsenical pyrites occur in considerable quantities as accidental constituents. In certain places, however, the hornblende-gneiss appears more independently and less interstratified with the rocks here described. Such is the case to the south of Helsingfors, at Boe, and in Lill Perno Bay near Borgå. Here it often contains a quantity of calcite grains, which by weathering out cause it to acquire a very riddled appearance, and it is much intersected and broken through by granite veins and dykes.

A specimen of the rock from Boe was examined microscopically by Castrén, who says: "The rock principally consists of hornblende and felspar, the latter generally being triclinic. The hornblende forms single grains, which are well shaped and occur as dark and light varieties, and the rock sometimes contains small quantities of a mineral of the pyroxene group. A section of a small crystal of this mineral that, having grown into a hornblende crystal, had fragmentary crystallographic surfaces, showed distinct and less distinct pinakoidal cleavage, and extinguished polarized light in a direction parallel to the plane of cleavage, the plane of the optic axes being normal to the plane of most perfect cleavage. Another section, in which the cleavage planes were parallel, showed an extinction angle of 30°. This points to the crystal being diallage. Prismatic cleavage was not perceptible in the first section, and in it the prism was more developed than the pinakoid. Apatite and derived epidote grains occur as accidental constituents."

Another specimen from Stigsböle was found by Castrén to consist of triclinic felspar and hornblende both of the dark and light green variety, together with quartz and a certain amount of magnesia mica.

As mentioned above, the hornblende-gneiss is frequently intersected by and interbedded with granite to such a degree as to render it difficult to determine which rock is present in the greater quantity. At Mortsjö, one of the many places where this phenomenon occurs, the plainly stratified hornblende-gneiss passes into a fine-grained indistinctly foliated rock, resembling a syenitic granite. We thus have here a case that is in all probability one of a gneiss metamorphosed by contact with a granite of similar age to itself, a fact which certainly speaks strongly in favour of the theory that gneiss was originally deposited as such, and has not received its present constitution *exclusively* through the action of chemical, thermic or mechanical metamorphism.

Mica, Hornblende, and Actinolite Schists occur at many different places, although not in such a manner in the south and west of the country as to entitle them to be considered as constituting a distinct formation. On the contrary, they form comparatively thin bands interbedded with gneiss, into which they often gradually pass. The mica-schist, the passage of which into gneiss is most frequently observed, consists as a rule of black mica and greyish-white quartz. Sometimes, as occurs near Hirvela, thin bands of mica-schist are found alternating with micaceous gneiss, the layers of each rock, however, being sharply separated from each other in such a way as strongly to suggest the sedimentary origin of the whole. More sparingly bands of hornblende-schist have been observed. They consist as a rule principally of hornblende and some black mica, in addition to which red orthoclase and white plagioclase are occasionally though seldom found. The cleavage is generally determined by the mica. The actinolite schists play much the same role as the hornblende schists, which frequently pass into them. Under the microscope they are found to consist in the main of actinolite and quartz, and sometimes contain plagioclase and suggestions of chlorite. Copper ore is frequently to be observed in this rock, and in it occur the celebrated copper deposits of Orijärvi.

Non-Foliated Rocks.

Quartzites and Fibrolite Quartzite.—Quartzites occur in considerable amount throughout the whole district; seldom, however, independently, but generally interbedded with mica-schist, which by gradual loss of mica frequently passes into it. The quartzite at times seems to form a line of separation between the mica-schists and limestone strata, especially in the neighbourhood of diorite schists, as near Orijärvi, in which situations it is often sandstony in appearance and fissile. In Tavastland quartzite occurs on a much more extended scale, forming hills of sufficient size to constitute conspicuous features in the landscape. Thus, near Turismaa, there is a narrow elevation some three miles in length by one mile and a half in breadth, composed entirely of quartzite striking E. and W. Under the microscope this rock was found to consist almost exclusively of quartz, with a thin skin of weathered iron oxide. A light-red mineral—fibrolite—also occurs in small quantities, but is

nevertheless present in sufficient amount to give the whole rock a very characteristic appearance.

Pyrargyllite, hornblende, and tourmaline occur as accidental constituents. The fibrolite needles are sometimes clustered together, sometimes arranged radially round a transparent nucleus and usually pierce the quartz. The whole rock has been enormously crushed and sheared, and would seem in every way to resemble closely the quartzite of the "Pfahl" in the Böhmer Wald (described by Gümbel, "Ostbayerische Grenzgebirge"). On its northern side it occurs in contact with a peculiar rock—a kind of quartzite-gneiss or quartzite-breccia, which the microscope shows to be a hornblende-gneiss infiltrated with quartz. It has been thought possible by several geologists that the quartzite of the "Pfahl" may be of eruptive origin. There is much to favour the same opinion being held of the Tavastland quartzite. Among the principal grounds which may be urged in its support, the occurrence of this contact alteration of the surrounding gneiss is certainly of importance.

Crystalline Limestones.—The crystalline limestones interbedded with the gneiss formation are of considerable interest, both from the regularity with which their strike follows that of the gneisses, from the number of accessory minerals which, as is usual with the Laurentian limestones, they contain, and from the very interesting contact phenomena with granite which they display. The rock is generally coarsely crystalline and of a pure white, though at times it passes into a fine-grained yellowish marble, as near Träskby. The accessory constituents most usually found include felspar, augite, serpentine, graphite, pyroxene, malakolite, condrodite, and wollastonite. The latter mineral has been observed near Yttela, where the limestone occurs in contact with eurite-gneiss. Most generally the limestones occur completely surrounded by granite. A typical contact presents the following features:—The limestone is coarsely crystalline, and the surface of contact smooth and irregular in outline; the granite, which is likewise coarse-grained, is covered by a brown talc-like skin, and is completely free from any veins of limestone projecting into it; the skin intervening between the two permits the limestone to be easily pulled apart from the granite. At times a band, some feet thick, of white oligoclase intervenes between granite and limestone, and the granite shows a disposition towards parallelism of arrangement owing to the occurrence of layers of biotite. Near Kaukelmaa occur some small bands of limestone surrounded by and mixed up with greyish eurite destitute of distinct strike—the whole apparently being a fragment uplifted by granite. The coarsely crystalline structure of the limestone in proximity to the granite (as above described) renders the opinion tenable and even probable that the latter rock has been deposited from hot springs which have found their way up through clefts in the granite from below. Limestones of a similar kind are also found in conjunction with pegmatite in veins penetrating gneiss.

(*To be continued.*)

IV.—On *Rhynchopygus Woodi*, Forbes sp., from the English Pliocene.

By J. Walter Gregory, F.G.S., F.Z.S.,
of the British Museum (Natural History).

Echinarachnius Woodi was founded by Forbes in his "Monograph of the Echinodermata of the British Tertiaries"[1] on two fragments from the Red Crag of Suffolk; of all the species described in that work, this has been regarded as the most interesting and problematical. As this species certainly belonged to a genus now foreign to the British or European seas, it was felt, that if its correct generic position could be determined, it and *Temnechinus* would indicate the true affinities of the Crag Echinoderm fauna, better than the cosmopolitan genera with which they were associated.

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Prominent attention was thus directed to the specimen as, had this view been correct, the fragment would have been the sole fossil representative of the Pourtalesiadæ. Prof. F. Jeffrey Bell, at the request of Prof. Svén Lovén, made a careful examination of the specimens, which had then been acquired by the British Museum, but concluded that they were too imperfect for any definite decision as to their affinities to be made. Professors Lovén and Bell however both agree that "there seems to be no reason whatever for regarding it as having been part of something like a Pourtalesia."[3]

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Prof. Forbes' reason for referring these specimens to *Echinarachnius* is not at all apparent. This genus had been well diagnosed by Agassiz and Desor,[1] a few years before Forbes wrote, and his own specimens differed from this in nearly every particular. The absence of actinal furrows, jaws, internal pillars and partitions; the presence of phyllodes; the equality of the ambulacra, the tumidity of the ambitus, and the excentricity of the peristome, together form a combination of characters which necessitate the removal of the species from *Echinarachnius* to a genus of a different order, viz. from the Clypeastroida to the Spatangoidea. The marked floscelle shows that it belongs to the Cassidulidæ, and the transverse anus and supra-anal rostrum prove that it belongs to the genus *Rhynchopygus*.

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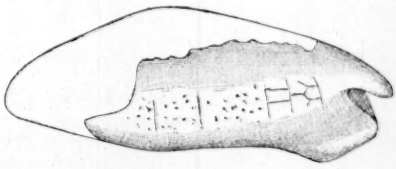
Outline seen from above elliptical, broadest at a quarter of the length from the posterior end; the supra-anal rostrum forms a conspicuous projection on the posterior margin. In elevation the species is seen to be depressed, with the apex at the anterior third: the anterior margin is sharper than the somewhat tumid lateral margin. The posterior extremity is rendered apparently vertical owing to the projection of the rostrum.



The apical disc is situated at the vertex.

Ambulacra subpetaloid, and open below: flush with the test: pores distant.

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[1] Catalogue Raisonné des Echinides, Ann. Sci. Nat. Zool. (3) vol. vii. p. 133, 1847.

IV.—On *Rhynchopygus Woodi*, Forbes sp., from the English Pliocene.

By J. Walter Gregory, F.G.S., F.Z.S.,
of the British Museum (Natural History).

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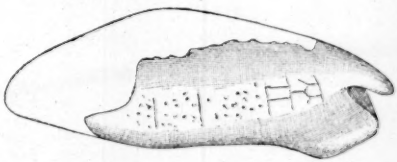

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Mouth anterior: situated in the deeper part of the depression. Floscelle well marked.

Periproct wide and forming a deep concavity in the posterior margin: it is protected above by the prominent supra-anal rostrum.

Tubercles small in impressed areolæ: generally uniform, but largest along the actinal area.

Dimensions—Calculated from Prof. Forbes' type (fig. 5).

Length	48 mm.
Width: at apical disc	34 ,,
,, maximum	40 ,,
Height...	15 ,,

Distribution—Coralline Crag, Layston Road Pit, Aldborough [Brit. Mus. E. 3207]. Red Crag: Bullock Yard Pit?[1] The locality of the type specimens is doubtful. Forbes mentions none, but Morris[2] attributes the species to Suffolk. The condition of the specimens and matrix suggests Walton-on-the-Naze.

Affinities of the Species—The genus *Rhynchopygus* dates from the Cretaceous; from the species of this system and from the Eocene, viz. *R. marmini* (Desmoul.)[3] of the Maestrichtien; *R. pygmæus*, Dunc. and Slad.,[4] and *R. calderi* (d'Arch. and H.[5]), from the Ranikot and Khirthar series; *R. navillei*, Lor.,[6] *R. thebensis*, Lor., and *R. zitteli*, Lor.,[7] from the Egyptian Eocene,—*R. Woodi* may be readily distinguished by the greater development of the supra-anal rostrum. In this species it extends back as far as the end of the test, whereas in the above forms it occurs but as a more or less slight prominence, on the posterior slope. *R. siutensis*, Lor.,[7] also from Egypt, differs in its thicker margins and less conical abactinal surface. The remaining species of the genus, as at present limited, are two existing American forms, and with these *R. Woodi* is more nearly allied; *R. pacificus* (A. Ag.)[8] has a more central apical disc and a different general shape, the posterior side being more sloping and there is no lateral tapering towards the anterior. *R. caribbæarum* (Lam.),[9] found also in the Pleistocene of Guadeloupe is the closest ally of *R. Woodi*, and here again the greater prominence of the supra-anal rostrum in the latter forms a ready means of distinguishing them.

The affinity of *Rhynchopygus Woodi* to the two species last

[1] A. and R. Bell, "On the English Crags," Proc. Geol. Assoc. London, vol. ii. 1872, p. 197.

[2] Morris, Cat. Brit. Foss. 2nd ed. 1854, p. 78.

[3] Desmoulins, Etudes sur les Echinides, 1837, p. 360.

[4] Duncan and Sladen, The Fossil Echinoidea of W. Scinde, Pal. Indica. ser. xiv. vol. i. (3) fasc. ii. 1882, pp. 68–9, pl. xv. figs. 5, 6.

[5] D'Archiac and Haime, Description des animaux fossiles du groupe nummulitique de l'Inde, t. i. p. 352, pl. xxx. fig. 19. Paris, 1853.

[6] De Loriol, Monographie des Echinides contenus dans les couches nummulitiques de l'Egypte, Mém. Soc. phys. et d'hist. nat. Genève, vol. xxvii. i. p. 85–8, pl. iv. figs. 2–4.

[7] De Loriol, Eocaene Echinoideen aus Aegypten und der libyschen Wüste, Palæontographica, vol. xxx. (3) pp. 18, 19, pl. ii. figs. 9–12.

[8] Al. Agassiz, "List of the Echinoderms sent to different Institutions with Annotations," Bull. Mus. Comp. Zool. vol. i. No. 2, p. 27, 1863.

[9] Lamarck, Hist. nat. anim. S. Vert, p. 349, 1801.

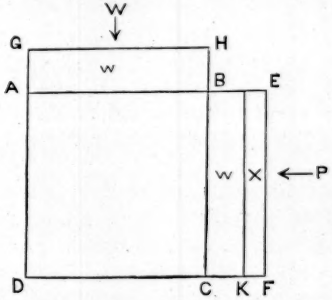
referred to is of interest as it serves to strengthen the resemblance of the English Pliocene Echinoidea to those of the West Indian area. The close connection between the echinoid faunas of the Tertiary deposits of the Antilles and of the Mediterranean subregions has been frequently insisted upon, notably by Prof. Al. Agassiz.[1] Hence the resemblances noted by Forbes between the Crag species and those now living in the Mediterranean do not diminish the more intimate connection of the former with the present West Indian fauna.

As far as can be judged from our present knowledge of the recent and fossil distribution of *Rhynchopygus*, it lived in the seas of the Palæarctic region from the Cretaceous to the Pliocene; about the latter period it migrated westward, for *R. Woodi* is apparently the last European representative, and it does not seem to have been recorded from the rich faunas of the West Indian Miocene. It now survives only round the shores of the Mexican and Antillean subregions of the Neotropical region. The genus is in fact confined to the littoral zone of a tropical sea, and it is difficult to see how it could have crossed the deep and cold abysses of the Atlantic. Hence either the European Miocene and Pliocene Echinoidea must have migrated westward along a belt of the continental zone that then stretched across the temperate regions of the Atlantic; or, the Echinoid fauna of the West Indies and the European later Tertiaries must have both originated from one that occupied an area of comparatively shallow sea somewhere in the North or Central Atlantic.

V.—On Dynamo-Metamorphism.

By the Rev. O. Fisher, M.A., F.G.S.

I HAVE derived much help towards understanding Mr. Harker's instructive letter upon the above subject from making the following simple geometrical construction.



Suppose *A B C D* to be the section of a cube of the contorted rock.

For simplicity we may suppose that the contorting pressure *P* has been met by a fixed abutment at *A D*. Suppose that in the process the mass *B C F E* has been forced past *B C*, and that the result

[1] "Challenger," Rep. Zool. vol. ii. p. 30.

has been that a quantity $G\,A\,B\,H$ of rock has been forced up to a height w above its original level $A\,B$.

Divide the distance between $B\,C$ and $D\,F$ into w and x; w being equal to the height w, to which $A\,B$ has been lifted. Let W be the weight of the "cover." Then the work done by P upon the original mass of material has been $P\,(w + x)$; and the work done by the material in raising the cover has been $W\,w$. Their difference is the work expended upon the mass $G\,D\,C\,H$, and it is $P\,(w + x) - W\,w$; or, $work = (P - W)\,w + P\,x$.

Now since the volume $B\,G$ equals the volume $B\,K$, it is obvious that the volume $K\,E$ has disappeared during the compression. Hence, $P\,x$ expresses the work of condensation. Consequently $(P - W)\,w$ must express the work of shearing expended upon the rock.

We must now inquire into what forms of energy the work has been converted. And first of the work of shearing.

This is converted,

(1) Into the potential energy implied in the raising of the centre of gravity of the mass through a height $\frac{1}{2}\,w$.

(2) It is employed in bending and breaking the rock, and overcoming friction. Since this part of the energy is not reconvertible into mechanical work, it must take the molecular forms of heat and chemical action, the effects being most concentrated where the mechanical action has been greatest.

The work of condensation $P\,x$ goes wholly to increase the results of (2); but the distribution of the effects will be more uniform than of those caused by the shearing.

To estimate the effect of the "cover" we observe that, as the cover is increased, W is increased, and of course P must also be increased, because it will require a greater force to lift a greater mass of overlying rock. But if instead of rock we had a liquid mass, we see that if P would lift W, $P + Z$ would equally lift $W + Z$, while, although the two pressures are equally increased, their difference remains the same. It seems probable, therefore, that, if the rigidity of the rock were to remain unaltered, $P - W$ would not be affected by a change in the quantity of cover. Hence, the work of a given amount of shearing expended upon the mass will not be affected by the amount of cover, except in so far as additional pressure increases, by closeness, the rigidity and frictional resistance of the substance, and so, when W is increased, requires P to increase at a more rapid rate than W. This appears to be a reason why dynamo-metamorphism may be greater at greater depths.

Mr. Harker seems to be of opinion, "since energy not lost by conduction must be absorbed in the production of mineralogical changes," that, where there is little hindrance to conduction, such changes will be smaller. But this conclusion does not follow unless heat longer retained is rendered conducive to mineralogical chemical reactions by the consequent increase of temperature. Appropriate elevation of temperature will no doubt help to promote chemical reactions. But in so doing does the heat disappear as heat?

In the case of a freezing mixture I suppose it does so, but such a case would not occur among minerals. Some geologists think that dynamo-metamorphism takes place *viâ* heat; but I am inclined to think that the energy developed by the work upon the rocks takes at once the form of chemical energy, without passing through the intermediate stage of heat. I should like to hear what is thought on this question by those who know.

In the case of the Bude rocks, and of the similar series at Tenby, I suppose that the movement took place at the same time as that of the disturbance of the Carboniferous rocks of the West of England. The Poikilitic series, which is the next in sequence, has not partaken of this disturbance. Hence, it is possible that the "cover" at the time of the disturbance was not great, and this will go some way to account for the small amount of metamorphism observed by General McMahon. Perhaps, also, the argillaceous beds may have acted as lubricants, and diminished the friction, thus reducing the magnitude of the force $P - W$, and the corresponding work expended on the rocks.

Harlton, Cambridge.

VI.—Note on a Pliocene Mammalian Fauna at Olivola in the Upper Val di Magra (Prov. Massa-Carrara), Italy.

By C. J. Forsyth Major, M.D.

FOSSIL Mammalian remains from Olivola were already known in the last century. Giovanni Targioni Tozzetti describes and figures several bones from that locality, which he refers to some species of *Trichechus* or *Phoca*, but which, as far as the figures permit of a judgment, belonged to Ruminants.[1] In this century, the deposit was mentioned by Pareto,[2] and by Cocchi,[3] who from stratigraphical considerations ascribe it to the Pleistocene.

A few remains from this locality, collected by Prof. Cocchi and Prof. Capellini, are preserved in the museums of Pisa and Florence, and in that of Bologna. Rütimeyer has made known an imperfect skull of an Antelope (*Palæoryx Meneghinii*, Rütim.) from Olivola, preserved in the Pisa Museum.[4] He, too, divides the opinion of the before-mentioned Italian geologists as to the geological age of the deposit, which he calls an Ossiferous Breccia. As, however, the skull of Antelope in which he recognizes a type from Pikermi, points to an older horizon, he supposes it to have been floated into this "Breccia" from an older deposit.

[1] Giovanni Targioni Tozzetti, Relazione d'alcuni Viaggi fatti in diverse parti della Toscana, ed. seconda, t. x. 1777, pp. 386–395, tav. i.

[2] L. Pareto, Note sur les subdivisions que l'on pourrait établir dans les terrains tertiaires de l'Apennin septentrional (Bull. Soc. Géol. de France, 2e série, t. 22. (Séance du 20 févr. 1865).

[3] I. Cocchi, L'Uomo fossile nell' Italia Centrale, Studi Palænotologici (Mem. Soc. Ital. Scienze Natur. vol. iii.), Milano, 1867, pp. 34–36.

[4] L. Rütimeyer, Die Rinder der Tertiaer-Epoche, nebst Vorstudien zu einer natürl. Geschichte der Antilopen (Abhh. Schweiz. Palæont. Gesellsch.), vol. iv. Zurich, 1877, 1878, fasc. vii. figs. 13, 14, pp. 86, 87.

An upper jaw of *Equus* from this same deposit, preserved in the Museum of Pisa, has been described by me as *Equus Stenonis*, Cocchi. On that occasion I gave my reasons for retaining it as of Pliocene age, relying on the few mammalian remains known at that time.[1]

During the autumn and beginning of winter of 1889, I had an opportunity of undertaking some excavations at Olivola, which brought to light a rich Mammalian fauna of undoubtedly Pliocene age, that is, contemporaneous with the Val d'Arno fauna. I was prevented through illness from terminating the work; but the results already obtained are deserving of mention, as besides some quite new forms of Antelope, up to this day fifteen species have been discovered, most of which are components of the Val d'Arno fauna, and are represented partly by much more complete remains than even the rich Florentine Museum can boast of.

Carnivora.—The genera *Felis*, *Machairodus*, *Hyæna*, *Canis*, *Ursus* are represented. The remains of *Felis* (two crania, two lower jaws and several leg bones) belong to a large form which may be provisionally referred to the *Felis arvernensis*, Cr. et Job.

Machairodus.—Several upper canine teeth of *M. cultridens*, Cuv., and a nearly complete hinder leg.

The remains of *Hyæna* belong to the larger Val d'Arno form, named by Weithofer *H. robusta*; right and left maxilla of a young individual, with the milk dentition still in situ; several lower jaws, and various bones.

The remains of *Canis* are very numerous, and partly in a fine state of preservation. Several skulls and nearly all the parts of the skeleton have been secured. The majority of these remains belong to the species described by the present writer under the name of *Canis etruscus*; but there is a larger form too, which may prove to belong to *Canis Falconeri*, Major, incompletely known at present.

The *Ursus etruscus*, Cuv., which, as well as all the other forenamed Carnivora, has not hitherto occurred frequently in the Val d'Arno, is well represented at Olivola by an incomplete skull, various upper and numerous lower jaws, besides bones of the skeleton.

Rhinoceros etruscus, Falc.—A complete cranium, with adhering mandibula, several other crania, less complete, several mandibulæ, and numerous other remains.

Equus Stenonis, Cocchi.—Two crania; mandibulæ; numerous bones.

Mastodon arvernensis, Cr. et Job., is for the present represented only by the proximal parts of a cubitus and radius.

Sus Strozzii, Menegh.—A skull and various mandibulæ. A lower canine tooth of *Sus* from Olivola, deposited many years ago in the Museum of Pisa by Prof. Cocchi, was declared by Rütimeyer[2] to be indistinguishable from the corresponding canines of the living *Sus scrofa*. A comparison, however, with the lower canines of living

[1] Forsyth Major, Beitraege zur Geschichte der fossilen Pferde insbesondere Italiens, IIter Theil. (Abhh. Schweiz. palæontol. Gesellsch. vol. vii. 1880, pp. 124, 125, Taf. iv.).

[2] *loc. cit.* p. 86.

and Pliocene species shows it to agree exactly with the latter, the outer plate of enamel being as large from behind forwards as the inner, as is the case also in the Siwalik species, and in the living *Sus celebensis*, Müll. & Schleg., and *Sus verrucosus*, Müll. & Schleg., from Java, whilst in *Sus scrofa* the outer side is very narrow from behind forwards. The more complete remains of *Sus* found last year at Olivola have placed beyond doubt their identification with *Sus Strozzii* from the Val d'Arno.

Ruminantia.—Numerous pieces: skulls, jaws and other parts of the skeleton of at least three forms of *Cervus*, the largest of which, in the form of the antlers, comes very near to *Cervus dicranius*, Nesti. The other cervine remains have not yet been satisfactorily identified with known Pliocene species, their preparation not being as yet advanced enough.

Of *Bovine* animals the deposit has yielded several crania of a hornless form; one incomplete cranium provided with horns; besides numerous other parts of the skeleton.

Since Prof. Rütimeyer examined the remains of bovine Ruminants from the Val d'Arno deposited in the Florentine Museum, several valuable pieces have been added to that collection. These, together with the skulls discovered at Olivola, have been lately re-examined by me, and the result is that I in some respects disagree with Rütimeyer's views on the subject. It will be remembered that Rütimeyer placed the hornless crania of the Val d'Arno in the genus *Leptobos* (*Leptob. Strozzii*, Rütim.), represented in the Siwaliks by horned and hornless (female?) crania of the *Leptobos Falconeri*, Rütim., and in the Pleistocene of the Narbada Valley by a hornless cranium, named *Leptobos Fraseri*, Rütim.[1] For my part, I cannot discover any differences between the crania of "*Leptobos Strozzii*" and "*Bos etruscus*," besides those which are the consequences of the presence or absence of horn-cores. The same opinion was expressed by me many years ago, when I declared the hornless skull in the Florentine Museum a mere variety of "*Bos etruscus*," suggesting that it was probably the female form.[2]

As, moreover, the differences between the horned crania of *Leptobos Falconeri*, Rütim., on the one hand, and of *Bos etruscus*, Falc., on the other, which have induced Rütimeyer to place the first in his group of the *Portacina*, the second in the *Bibovina*, are not marked enough in my opinion, there being several transitional forms in the various known crania of *Leptobos Falconeri*, as well as in those of "*Bos etruscus*," the only way of resolving the question seems to me to include all the known remains of bovine animals of the Italian and French Pliocene in the genus *Leptobos*. The synonymy of the only species therefore runs as follows:—

LEPTOBOS ELATUS (Croizet sp.).

1828. *Bos elatus*, Croizet, Coll. Mus. Paris.
1854. *Bos elatus* and *Bos elaphus*, Pomel, Catalogue Méthodique.

[1] L. Rütimeyer, Die Rinder der Tertiaer-Epoche, etc., p. 157, seqq.
[2] Forsyth Major, Nagerüberreste aus Bohnerzen Süddeutschlands und der Schweiz. Palæontographica, ii. 2 (xxii.), 1874, p. 123.

1859. *Bos etruscus*? Falconer MS., cf. Palæontological Memoirs and Notes, ii. p. 481.
1866. *Bos* (*Bibos*) *etruscus*, Rütimeyer, Versuch einer natürl. Geschichte des Rindes, etc. ii. p. 71, seqq.
1874. *Bos etruscus*, Forsyth Major, Nagerüberreste aus Bohnerzen Süddeutschlands und der Schweiz, Palæontographica, ii. 2 (xxii.), p. 123.
1877–8. *Bos* (*Bibos*) *etruscus*, Rütimeyer, Die Rinder der Tertiaer-Epoche, Abhh. Schweiz, Palæont. Ges. p. 154.
1877–8. *Leptobos Strozzii*, Rütimeyer, *ib.*, pp. 167, 168, 173, 175.
1884. *Bos elatus*, Depéret, Nouvelles études sur les Ruminants pliocènes et quaternaires d'Auvergne (Bull. Soc. Géol. de France 3e série, t. xii. p. 247).
1885. *Bos elatus*, Lydekker, Catalogue of the Fossil Mammalia in the British Museum (Nat. Hist.), part ii. p. 19.

The *Rodentia* are for the present represented only by a large incisor, referable to the genus *Castor*.

VII.—On the Base of the Sedimentary Series in England and Wales.

By the Rev. Prof. J. F. Blake, M.A., F.G.S.

As Dr. Callaway has asked in a recent Number of the Geological Magazine[1] for the grounds on which I suggest that some of the volcanic rocks of Shropshire may perhaps be classed as Cambrian, I take this opportunity for bringing before your readers the present state of the inquiry into the nature and classification of the earliest sedimentary rocks in this country. This inquiry has been spoken of by Dr. Callaway as the "Archæan controversy"; but we must not necessarily call everything that is earlier than the Cambrian "Archæan," any more than in old days it was right to call everything Precarboniferous "unfossiliferous greywacké"; nor should the inquiry be considered a controversy in its present stage, but rather a search for more accurate knowledge.

Omitting the Charnwood Forest rocks, and the Caldecott ashes, about which there is little definite to say, the areas in which Precambrian rocks have been described are—1. St. Davids; 2. Anglesey; 3. North-west Carnarvonshire; 4. Malvern; 5. Shropshire; 6. Devonshire and Cornwall. I propose to point out, according to my view, our present state of knowledge, and the history of its growth, in each of these localities.

1. *St. Davids District.*—It appears that when this was mapped by Prof. Ramsay, before 1857, he recognized below the basal Cambrian conglomerates, besides a mass of crystalline rock, a series of more or less volcanic detritus and lavas, but that this recognition was never published. In its place was the indication that the latter were "altered Cambrian." In 1877, however, Dr. Hicks, considering that the Cambrian conglomerates, from the nature of their contents, and their apparent unconformity, indicated a greater break than had been recognized by Prof. Ramsay, set to work to describe the underlying rocks as distinct formations. He was also under the influence of theories of metamorphism; but whereas, in Prof. Ramsay's hands, these theories had led him to consider lavas and ashes as the

[1] Geol. Mag. Decade III. Vol. VII. p. 143, 1890.

altered representatives of ordinary sediments, in Dr. Hicks's, the crystalline masses were considered as stratified rocks whose bedding had been almost or entirely obliterated. In his original paper (1877) he stated that the "Dimetian series, near St. Davids, are chiefly quartz-schists, chloritic schists, indurated shales," while at Porthlisky "the quartzose beds are less altered," and "we find massive beds of calcareous shale and chloritic schists, and associated with them also dolomitic limestone beds several feet in thickness." The series was stated to have a constant strike to the south-east, and to be 15,000 feet at least in thickness – a very definite description. The "Pebidian" had a strike nearly at right angles to this, and "consist chiefly of indurated shales, often porcellanitic in character," while "the lower beds, resting immediately on the Dimetian axis, are hard compact conglomerates chiefly composed of masses of quartz and altered shale, or such masses as might have been derived from the underlying rocks," and on the west side the appearance of the rocks is much like that at St. Davids, but there is a larger proportion of greenish and purplish schists alternating with the compact porcellanite shales, "so that there is every probability we have a repetition of the whole series," and "on the S.W. of Ramsey Island the beds are compact porcellanites like those near St. Davids, and the bedding is also easily traced."

Such was the original description—in which it will be noticed that there was not a single word about granitoid rocks, quartz felsites (except as a dyke), agglomerates, or volcanic ashes.

In the following year, however (1878), he had gone over the ground again in company with Mr. Hudleston and Prof. Hughes, and it is not too much to say that in all essential features, the lithological description of the rocks were entirely altered, so that it is not difficult to say *who*, rediscovered, so to speak, the volcanic series. Now we hear that the Dimetian consists of "quartz porphyries, fine-grained quartz-felsites, ashy shale-like rocks (which turn out to be altered basalts), compact granitic-looking rock, quartziferous breccias, granitoid quartz schists somewhat chloritic, schistose bands which are also basalts, and crystalline limestone bands." Thus the quartz schists turn out to be for the most part granitic-looking rocks and quartz porphyries, the indurated shales are basalt dykes, and the dolomite beds several feet in thickness are calcareous infiltrations along joints. It will be noted also that the quartz porpyhries and felsites are placed at the base of the series. It is still maintained, however, that the whole is bedded. Passing to the Pebidian, we now hear of agglomerates at the base, felspathic breccias, indurated ashes, volcanic tuffs, conglomeratic and ashy beds, a thick band of felstone, probably a contemporaneous lava, and bright green ashes, in addition to the porcellanites, schists, and conglomerates, which alone made up the series before. Moreover, the beds on the west are not now repetitions of those on the east, but higher in the series, while the mass in Ramsey Island, instead of being a bedded porcellanite, consists of felstone, felstone porphyry, hornstone, and felspathic breccias. It is scarcely possible to imagine a more complete

change of description. We are now told that "the general likeness in the whole series to a group of volcanic rocks found in more recent strata is most marked, especially to those associated with the Lower Silurian," a remark which never could have been made at the close of the *former* description. Almost the only statements that remain the same are that the Dimetian is bedded, and that the Cambrian conglomerates "almost invariably for the most part consist of the fragments of the rocks on which they lie."

After such a change as this it is important to remark that the conclusion Mr. Hudleston arrived at was that the "Dimetian" represented the hypogene condition of a group of which the "Pebidian" was the surface product—a conclusion which negatived any bedding in the former, or any great difference in age between it and the latter.

A year later Dr. Hicks visited the district east of St. Davids, and examined the rocks at Roche and Treffgarn, which Murchison had previously described as felstones, intrusive into the Cambrian rocks amongst which they occur, but which Dr. Hicks described as bedded, and accepted Mr. Davies's name of Halleflinta. For this he created a new group, the "Arvonian," and referred to it the quartz porpyhries of St. Davids, which the year before he placed at the base of the Dimetian, but now placed above it and unconformable to it, without giving any definite reason for the change.

Dr. Geikie's examination of the district in 1883 gave a new complexion to the whole matter. He showed that the whole of the "Dimetian," as last restricted, was nothing but a granite throughout, and stated also that it was intrusive into the Cambrian. In the first of these conclusions he was supported by Prof. Renard, and by all subsequent observers, as he had practically already been by Mr. Hudleston, but the supposed evidence of the second point has not been considered sufficient for its proof. The quartz porphyries which had been called "Arvonian" he considered as apophyses of the granite; and as regards the "Pebidian," while accepting the *later* petrological descriptions of Dr. Hicks, he minimized the separation between this and the Cambrian conglomerate, and challenged Dr. Hicks to prove his statement that the latter is chiefly composed of "fragments of the rock on which it lies." This Dr. Hicks has never been able to do, seeing that the most marked feature of the conglomerate is that it is *not* composed of such fragments; instead of doing so, he now attempts to show that the matrix might have been derived from granitoid rocks.

My own observations, while coinciding with the general ideas of Dr. Geikie, and differing chiefly on the question of how far the granite intrudes, led me to think the gap between Cambrian and Pebidian a wider one than he admits. Recently Prof. Lloyd Morgan, going over the same ground, brings them closer together again.

As to the "Arvonian" in its typical locality, I have shown that the supposed bedded halleflinta at Roche is nothing but a silicified andesite, and this determination has been accepted by Prof. Bonney and others and thus—exit Arvonian.

With regard then to the St. Davids district, the net result of past researches amounts to this. There are below the Cambrian conglomerates a series of bedded rocks, partly of volcanic and partly of sedimentary origin. Associated with these there is a mass of granite which is bounded in many places by quartz porphyrites. The granite is not actually seen to intrude into anything, but the quartz porphyries may be either its apophyses, or a later eruption which is more or less intrusive into both it and the volcanic ashes. The whole of this group is distinct in character from the Cambrian rocks which succeed (with insignificant exceptions), and there is an interval of time between them; but of what amount, or of what importance, this interval may be, is at present an open question, probably not to be settled without introducing considerations derived from other areas. All this does not seem to be more than might have been made out by a good geologist working for a fortnight on the ground, but the labour that has been spent will not have been thrown away, if we are taught caution in the use of theories of metamorphism from the utter failure of even geologists of credit to make out bedding in massive crystalline rocks which we might as soon expect to discover as the original stratification of an earthy iron ore in a bar of pig iron made from it.

To the series thus determined—whether it be a subdivision of the Cambrian or a portion of an anterior system of rocks—the "local name" of Pebidian rightly belongs. The use of the same word for any minor group in other areas depends on a more accurate correlation than has yet been accomplished.

2. *Anglesey.*—In his earliest classificatory paper, Prof. Sedgwick placed the older rocks of this island in his Lower Cambrian group, making what is now known as Cambrian proper his Middle Cambrian, while our Ordovician rocks were his Upper Cambrian. In later writings, however, he excluded the Anglesey rocks from the Cambrian, which he then made to commence with the "Llanberis slates." In deference, however, as it seems, to the views of the Geological Survey, he left it an open question whether the Anglesey rocks might not be altered representatives of some part of his Cambrian system, though it is obvious that he did not of his own accord consider them as such. With regard to the opinion of Prof. Ramsay that all the older rocks of Anglesey were metamorphosed representatives of the Cambrian, we need not imagine that he supposed they were the very same beds as are seen on the mainland continued into the island in an altered state, but that he found no line of demarcation between them, and no necessity to consider them of a different system, but rather as a downward extension of the Cambrians which were here entirely metamorphosed. Such appears also to have been Sedgwick's original opinion when he called them "Lower Cambrian." And such for many years, in deference to the deservedly respected teaching of Prof. Ramsay, they were held to be. As soon, however, as attention began to be turned to possible Precambrian rocks, Anglesey was naturally thought of. Accordingly, in 1878, Dr. Hicks examined the junction of the granite at Llanfaelog with the

overlying conglomerates, and found that the latter was made out of the fragments of the former. In the same way Prof. Hughes, near Llanerchymedd, and Mr. Roberts at Penlon and Nebo, found conglomerates at the base of the so-called "Silurian." From the running of the line of junction on the Survey map, and the conspicuous character of the conglomerates along this line, it is obvious that these facts were perfectly familiar to Prof. Ramsay. Why then did he not, like Dr. Hicks and Prof. Hughes, consider them to prove the Precambrian age of the granite and associated rocks? The answer is obvious. He mapped the conglomerates not as Cambrian but as Silurian; and the evidence on which he did this is equally plain. The only fossils ever obtained in the rocks which lie conformably above the conglomerates are such as need not be older than the Arenig. It is true that at Llanfaelog there is a good quantity of grit between the fossils and the conglomerate; but this is not the case elsewhere, and we do not know whether there are any strike faults here or not. It is therefore an entirely ungrounded assumption that the conglomerates are basal Cambrian, in the sense that they underlie the diminished representatives of Menevian, Lingula Flags, and Llanberis slates. Dr. Hicks has therefore in no way proved that the rocks are Precambrian, or brought the slightest evidence against the conclusions of Prof. Ramsay. The first real evidence of this kind is that supplied by Dr. Callaway. By his description of the rocks and demonstration of their great complexity and thickness, he rendered it obvious that so distinct and vast a group could not be a mere downward extension of any other group, but must be worthy of a place apart. If any place apart is assigned to it, this must be below the Cambrian.

But unless we can show an unconformity between these and the true base of the Cambrian, the separation remains a matter of appreciation only. Fortunately the very spots where Prof. Ramsay read continuity, by being better exposed now prove unconformity. Thus on the east of the island near Beaumaris, Prof. Bonney has shown that, the lower rocks, which are continuous across the island, and of the same general character as the rest, are either overlaid by, or are faulted against, a peculiar group of stratified rocks largely composed of volcanic materials, and by tracing it further I have shown that the junction is a real unconformity. Now these upper rocks are continued into the mainland, and there we learn by stratigraphy that they cannot possibly be younger than basal Cambrian in the most extreme sense of the word. From whence it follows that the underlying rocks are really Precambrian. It may be taken therefore as settled that the main mass of the schistose slaty and associated rocks of Anglesey belong to a period which antedates the Cambrian. This proved, three questions still remain, is this true of all of them? do they form one system or several? and can any part of them be correlated with the rocks of St. Davids?

In answer to the first question, Prof. Hughes has pointed out that in the Northern district the beds have a uniform dip to the north, and near the summit of the series, as thus ascertained, there

occurs a fossiliferous band containing *Orthides*, of which the most characteristic is *Orthis Bayleana*. Prof. Hughes's own solution of the difficulty thus arising appears to be that this is here a continuous upward sequence from the Arenig slates which occur in the centre of the island. This ignores the great fault by which the two are separated, according to every other observer. The only other solutions at present suggested are either that the fossiliferous bands are faulted in, or that the fossils are really characteristic of the Precambrian series. Against the former solution is the fact that the containing rocks are just like the rest for some distance north and south, and that no fault which should have the required effect can be seen, even by careful observation directed to this very object, in the adjacent clear coast sections. The only recognized faults in the neighbourhood let down narrow troughs of dark shales with Llandeilo Graptolites, which are therefore younger than the surrounding mass, and not older as they should be if the latter were of Bala age. Still, if the third solution be not accepted, the next most probable one would be the existence of some disturbance not as yet properly understood. The third solution, that the fossils found are characteristic of Precambrian rocks, seems too startling at first to be entertained at all—*Orthis* in Precambrians! Nevertheless there is something to be said on this point. The principal and in fact only definitely recognizable species is a very well marked one, and in spite of the abundant fauna of North Wales it has never been seen there, in any other locality. I have compared it with the type which comes from near Wexford, and there cannot be the slightest doubt that it is the same species, *Orthis Bayleana*. I have been to Wexford to try to learn its true position. But I never saw such a jumble of rocks as are there exposed; it is perfectly hopeless to learn anything of their position. But two things I learned, first, that this species nowhere occurs in the true slaty Ordovicians, which are not many miles away, and that the matrix is quite different. It is said to be associated with recognizable Trilobites, but these again occur in an entirely different matrix.

In answer to the second question—whether these rocks form one system or several—Dr. Hicks replies by implication that there are three, since in certain spots he thinks to recognize his Dimetian, Arvonian, and Pebidian. By the proof, however, which I have abundantly given, and which is for the most part now accepted, that the granite referred to the Dimetian is an intrusive rock, these reduce to two; but as no detailed observations bearing on the question have been published by this author, there is no occasion to discuss whether the remaining divisions represent real groups.

But Dr. Callaway's description is directly to this point. According to him there are two distinct groups, the "gneissic" and the "slaty." The evidence adduced in support of this is threefold. 1. That one of the "slaty" rocks contains fragments of a "gneissic" rock. 2. That at one spot a rock referred to the slaty group contains fragments of a granite referred to the gneissic group. 3. That the

lower group is much more altered than the upper. He affirms also that the two groups are always brought together by faults. Two of these proofs depend upon the detailed examination of isolated spots or rocks, and after having fully examined them, I have elsewhere given full reasons why they cannot be considered satisfactory. With regard to the third reason, it is generally true that the lower part is more gneissic than the upper, but this alone will scarcely be considered sufficient to establish the independence of two groups; nor does the author appear to lay great stress on this, but merely uses the terms as distinctive descriptive titles.

My own researches, which have been pretty exhaustive in every area, with the exception perhaps of the granitic portion in the centre, have shown that the gneissic portion is often slaty, and the slaty portion often gneissic; that the faults by which they are supposed to be separated cannot in most cases be traced in the field; and that there is so intimate a connection throughout between one part and another that they cannot be separated into two systems, though a more or less arbitrary line may be drawn between the upper and lower portion. Taken altogether they form so vast and complicated a system, as first shown by Dr. Callaway, and later by my own more detailed examination (which has led me also to include the rocks of Howth Hill and Bray Head in the same series), as to be comparable in extent and variety of forms, not with one zone of the Cambrian, but with the whole; and they are equally worthy with it, or with the Silurian, of distinct recognition, notwithstanding that it is at the present moment doubtful how far they are fossiliferous. It is for this reason that I call the whole the Monian system. It is more than probable that this, like every other system, may be usefully divided into several subordinate members, possessing distinct characters; and it is with such subordinate members that any of the groups elsewhere established amongst Precambrian rocks will have to be correlated, if they really correspond. I scarcely feel sure, however, that any such correspondence has as yet been made out, whatever may be the case in the future. Even so, however, the Monian system is no rival to any other group, being more comprehensive than any. It has been objected to this system that it has neither bottom nor top. As to the bottom, this can only be definitely fixed by finding a lower system still. At present it is the lowest system in the area, and the earth is its bottom; and if any other is found, it will probably be somewhere in the Highlands of Scotland—but not in Wales. As to the top, in Anglesey itself this is defined by the unconformable Cambrian, but the fact of this unconformity shows that there may be higher parts of it elsewhere. Such a higher part, for instance, I reckon the Bray Head rocks to be, which are separated from Anglesey only by the breadth of the Irish Channel. It has also been objected that if it is distinct from the Pebidian, it becomes equivalent to the crystalline schists, and as such requires no new name. This, however, is to misunderstand its nature; it is only partly schistose, and the special peculiarity of it is that it unites in one sequence true crystalline schists with ordinary sedimentary rocks.

When we come to the details of the development, new questions arise. With regard to the upper part, my own description, if somewhat fuller, agrees essentially with that of Dr. Callaway; but with the lower part this is not so. Dr. Callaway laid down a scheme of succession as follows, beginning at the base:—1. Halleflinta; 2. Quartz schists; 3. Grey gneiss; 4. Dark schist; 5. Granitoidite; every one of which were regarded by him as altered stratified deposits. This sequence is naturally objected to by Dr. Hicks as inconsistent with his own identifications. According to my own observations, the halleflinta is of no stratigraphical importance, the granitoidite is an intrusive granite, and under the term "dark schists" have been included two distinct groups of rocks, the truly stratified chloritic schists, and the finely foliated hornblende schists. Eliminating these, the remaining sequence between quartz schists, grey gneiss and chloritic schist, agrees very closely with my own arrangement. Dr. Callaway, however, has now come under the influence of the theory that foliation is produced by dynamical metamorphism, and this leads him to say that his "time succession" no longer holds. How far the above arrangement is withdrawn is not, however, quite clear. The character of the granite and halleflinta has nothing to do with this theory, since neither are foliated. In the case of the hornblende schist, the stratigraphical evidence of its sporadic development and its intrusive character have shown that it is a truly igneous rock which may once have been a dolerite; but the same evidence is entirely wanting in the case of the chloritic schist and grey gneiss, some of which latter Dr. Callaway now regards as an altered felsite.

The third question relates to the possible correlation of parts of this series with rocks elsewhere described. The intrusive granite has been called Dimetian. It may or may not be of the same age as the granite of St. Davids; the only connection between them is that both antedate the Ordovician, and both are granites. The "Halleflinta" has been called Arvonian; but the "Halleflinta" in Anglesey has no resemblance and no analogous position to any rock at St. Davids or in Pembrokeshire; the only connection between any two such is that both have been called by the same wrong name, neither being typical halleflintas. All the rest of the older rocks of the island were at one time called Pebidian by Dr. Hicks; they cannot *all* be, and nothing is more certain than that they are all distinct from the Bangor beds of Prof. Hughes, which have also been called Pebidian. Prof. Bonney, in his British Association address, clearly distinguished the two, and stated that the Anglesey rocks were older than those of Bangor, which latter he referred to the Pebidian. I myself originally referred the volcanic portion of the Monian to the Pebidian, and called it the "St. Davids group,"—a correlation dependent only on the facts that both are of volcanic origin, and both in some sense Precambrian; but the rashness of such a correlation is already clear. At the present moment, therefore, none of the Precambrian or Monian rocks of Anglesey have been definitely identified with any rocks elsewhere.

(*To be concluded in our next Number.*)

VIII.—Notes on the Probable Origin of Some Slates.

By W. Maynard Hutchings.

(*Concluded from page* 273.)

In the deposits previously described what takes place appears to be about as follows. The larger flakes of biotite undergo an alteration which largely produces epidote, and not improbably granular rutile, though this is not at all proved. *Crystals* of rutile very rarely result during the process. Such of the iron of the biotite as is not combined in the epidote (which is strongly coloured) is removed in solution, some of it being deposited again as limonite diffused throughout the deposit, and some taking part in the formation of the thin bands of ironstone, being precipitated as carbonate.

Saline solutions dissolve and carry away part of the silica; finally the whole of the constituents of the mineral are broken up, partly removed in solution, or diffused among the other materials of the deposit. Of the titanic acid contained much is probably removed in solution jointly with the silica, and this dissolved titanic acid may most likely, as Thürach suggests is the case in some sandstones and other sedimentary rocks, supply by re-precipitation (by means of carbonic acid or otherwise) and crystallization, the material for the secondary crystals of anatase. It may also, diffused through the mass, take part with the titanic acid of the smaller fragments of biotite in yielding the countless small crystals of rutile; and we may very reasonably ascribe to it partly also the formation of the thin plates of micaceous ilmenite.

The flakes of muscovite of anything like noticeable size do not appear to undergo any sort of change, so far as these particular deposits are concerned.

The small, and very small, flakes and shreds of biotite appear to undergo an alteration which differs in many ways from that suffered by the larger bits, and which seems to depend not merely on ordinary attack by water and by saline solutions, but to be also, and more largely, brought about by chemical inter-action between the biotite and other minute materials with which it is deposited in intimate contact. This fine mixture of biotite, muscovite, kaoline, the minutest waste of felspar,[1] and in less degree of quartz, and probably other substances, under the joint action of pressure, warmth, and mineral solutions, gives rise to various decompositions and re-

[1] The experiments of Daubrée (Geologie expérimentale, 1879) on the effects of the mutual attrition of fragments of granite in water, are of very great interest and bear strongly on the special point here in question. It is to be particularly noted that he shows how comparatively rapidly the *felspar* is reduced to the condition of the finest mud ("limon"); and further, that the felspathic mud so produced has not been simply reduced mechanically to powder, but has been *chemically* acted upon to a noticeable extent in a relatively short time. The felspar has given up some of its alkali to the water and has become hydrated by taking water into combination. The granite used in these experiments was fresh and its felspar not weathered.

This fine mud of hydrated felspar, so fine as to remain suspended in water several days, and depositing as a plastic mass, is in just the condition for rapidly undergoing chemical changes and acting powerfully upon the minute fragments of biotite, etc., with which it is intimately intermingled.

combinations, which result, among other things, in the formation of new mica, with the separation of titanic acid in the form of rutile.

Into these reactions, whatever may be their exact course, even the muscovite in very fine state of division appears to enter; and there is good reason to conclude that in fine-grained sediments of suitable composition, exposed long enough to the necessary conditions as to pressure, temperature and percolation of solutions, an almost complete regeneration of the "paste" to mica can and does take place, and that this regenerated material, under intenser dynamo-metamorphic action, is converted into some of the forms of micaceous slates known to us.

The mica so formed is probably what in its more advanced stages of development is often known as "sericite." This is usually stated to be only a special form of muscovite, but the term is really rather vague. Rosenbusch points out that some of the "sericites" of the phyllites show strikingly small optic-axial angles, and that probably more than one substance is included in the term. This would follow naturally from the mode of origin seen in these clays and shales, the proportions of the various ingredients of the deposits being liable to vary considerably. We are still very ignorant as to the exact composition of the micas, and the relationships of their optical and chemical properties.

Whether we call this newly-formed micaceous mineral sericite,[1] or leave it nameless, we may take it to be highly hydrated, and it seems justifiable to assume that it contains magnesia as part of its constitution. In these fireclays, though no trace of biotite may be visible to the most careful microscopic search, magnesia is nearly always present, and usually to an extent which would answer to a considerable percentage of biotite of the kind usual in granites.

Thus, in a list of analyses quoted by Percy, magnesia ranges up to 1·21 per cent., and a fair average may be given as about 0·75 per cent. For a comparison we may place this against analyses of granite, taking for instance those given of British granites by Teall (British Petrography), where the maximum of magnesia is 2·48 per cent., the Skiddaw granite containing 1·08 per cent. One fireclay examined by me, with no trace of visible biotite, contained, by most exact determination, 0·95 per cent magnesia.

If we now come to consider some of the older slates,—the roofing-slates of Wales and Cornwall,—it seems that much of what we have been able to observe in progress in the clays and soft shales of the Coal-measures finds considerable application, and throws light on some important points. Thus, not one of these slates which I have studied contains any trace of original biotite; and most of the Welsh, and all the Cornish (from Tintagel, Delabole and district) contain varying, and mostly large, amounts of rutile, in just the same form and mode of dissemination as the fireclays.

[1] Although "sericite" is now stated to be only a form of muscovite, and the use of the term is open to some objections, it will still be well to follow Rénard, who elects to continue its employment when writing of mica having the special physical characters which it shows in the class of rocks now under discussion.

Both the questions—why never any biotite, if we are supposed to have in these slates only consolidated and cleaved original deposits?—and whence all the evenly diffused rutile?[1]—appeared to me to need explanation till I examined less advanced stages of presumably similar deposits.

In many Welsh slates epidote is abundant, and in some of them just such clusters of plates are seen as I have above described. In others it is more often in larger, more solid lumps. We might expect great pressure to frequently solidify such groups of plates and grains; and of course epidote may be present from other sources than original biotite.

The base and main constituent of all these slates is a small-grained mica, mostly lying flat in the plane of cleavage of the rock.

I do not think it would be going beyond what is warranted if we were to conclude that markedly rutiliferous slates had resulted from deposits originally containing much biotite; that slates showing these platy pieces of epidote had formerly contained good large flakes of biotite; while slates containing little or no epidote, no coarse-grained quartz, felspar, etc., but rich in rutile, were formed from such fine deposits as we see in the finest of the fireclays. Again, slates with but very little or no rutile may have resulted from deposits free, or almost free, from biotite; but when grains of quartz, etc., indicate that the deposit was more or less coarse-grained, it is still possible that biotite was present in large flakes, which, as we saw, do not give rise to rutile directly; and if epidote were seen in the forms described, this supposition would receive considerable support.

The other things seen in the clays and shales are still to be found in the slates; the small plates of micaceous ilmenite (sometimes here in perfect hexagonal form), the numerous crystals of tourmaline, etc., etc.

Many of the Welsh slates are much more ferruginous than any of the fireclays, whether by original deposit or subsequent infiltration, and this ferric constituent, under dynamic action, has resulted in the countless transparent red scales of specular iron which give the colour to the various red, purple, etc., slates. Others are as free from iron as any fireclay of the Coal-measures, and all the Cornish slates are remarkably free from it.

A large part of the Welsh slates contains numerous original quartz-grains of various sizes, and felspar may be still recognized in some cases, fresh enough to give the optic figures. Small grains, both of quartz and felspar, are seen in some slates to be blending away into the surrounding mass.

[1] We are indebted to Rénard ("Recherches sur la composition et la structure des phyllades Ardennais," Bulletin du musée royal d'histoire naturelle de Belgique, 1882–1883), for a series of very careful analyses of phyllites, many of which very closely resemble those of North Cornwall.

In ten analyses the titanic acid present varies from 2·28 p.c. to 0·13 p.c., the average being 1·20 p.c.

In the same analyses magnesia ranges from 2·35 p.c. to 1·13 p.c. Combined water is mostly between 3 and 4 p.c., the maximum (unusual) being 4·94 p.c.

In no slate from Tintagel district have I detected a single grain of original quartz, nor any felspar. Secondary quartz is not uncommon, and all cracks are filled with veins of it. Even where no sign of it is seen with the microscope, analysis shows that more silica is present than could be accounted for in the mica, etc. Thus one such sample from Tintagel quarry contained 50·3 per cent. of silica, showing that an excess of that substance is diffused in some form among the other components.

These Cornish slates appear to have undergone far more dynamic metamorphism than the Welsh, and we should expect the obliteration of original grains of the deposit to have been more complete. From the almost total absence of epidote from the typical slates of Tintagel and Delabole, the smallness of the zircons (the one remnant of original deposit), and the large amount of rutile, I would infer that they were laid down as a very fine silt indeed, of granitic origin mainly.

In all these slates, Welsh or Cornish, however, the proportion and the size of the other constituents may vary, the fundamental base of mica is much the same in nature so far as can be made out with the microscope alone. I am unable to ascertain that any of the roofing-slates contain any residue which could be identified with the granular, impure "kaolinitic" material of the clays and shales. All this is apparently altered, the processes seen in progress in those earlier stages of metamorphism having been completed under the much longer and more intense dynamic action which the slates have undergone, clastic muscovite having also nearly totally disappeared.

This action has resulted, among other things, in dehydration, the combined water in slates being very much less than in shales and clays, however micaceous these may be. This combined water ranges about 4 to 5 per cent. in slates. It is often double and more in fireclays and shales.

So far as I am aware, we are not in possession of any exact knowledge as to the chemical constitution of the mica forming the base of the slates, and it would not be easy to obtain, owing to the difficulty of isolating any of this mica. We have an immense mass of analyses of "clay-slates" in bulk, and magnesia figures in nearly all of them. Thus, in 80 analyses discussed by Bischof (Chemische und physikalische Geologie), it ranges from a trace to 11·71 per cent. This maximum is quite exceptional, a good average would be from about 0·7 to between 2 and 3 per cent. Many slates contain chlorite, which may account for the magnesia in some cases, but many do not contain that mineral, or only very slightly. That magnesia is present—that the materials for biotite are contained in the slates—is shown also by the plentiful formation of that mineral, which is such a usual accompaniment of contact metamorphism, and which also often takes place in advanced dynamic metamorphism. I have not seen this dynamo-metamorphic biotite in any of my Welsh specimens, but it is strongly developed in some of the Cornish, and slightly in many. It is interesting to see, in among

the biotite and quartz of contact-slates, the abundant rutile-needles of the original slates (*e.g.* Shap, Skiddaw).

It may be noted that the chlorite which is so plentiful in some Welsh slates, and in most of the Cornish roofing-slates and allied material, appears to be wholly of later date than the rutiliferous sericitic mica, and in many cases to be due to subsequent deposit from infiltrations, such chlorite never showing any inclosed rutile, ilmenite, etc.

In other cases, however, it appears to be due to the more advanced stages of dynamic action, being then intergrown or twinned with muscovite, vertical or more or less highly inclined to the cleavage of the slate. In this manner of occurrence it sometimes contains rutile, and notably so in some Tintagel rocks.

The white mica which is formed with or without chlorite (or with ottrelite at Tintagel) lying otherwise than with the cleavage, appears to be true muscovite. It is present in some Welsh slates, absent from others, and very abundant in nearly all the Cornish slates, being always rich in inclosed rutile. It can all be seen to be due to later stages of dynamic action than that which arranged the main mass of the mica in one plane.

It may be well to bear in mind that though opinion is now mainly in favour of the belief that the mica of such slates as we have been considering is mainly or wholly secondary, and produced *in situ*, there is one very great authority on the subject who arrived at a quite opposite conclusion after much research.[1] Dr. Sorby, in his address

[1] At about the same date as Dr. Sorby's address, Pfaff published a paper on some more recent clay-slates ("Petrographische Untersuchungen über die eocänen Thonschiefer der Glarner Alpen," Sitzungsbericht der K. Bayer. Akad. der Wissenschaften, 1880). The examination of these slates and shales showed a "surprising amount of resemblance to the Palæozoic clay-slates" down to the presence of the "clay-slate needles." Pfaff arrives at the same conclusion as does Sorby as to the slates being simply compacted original sediments; but while Sorby seems to have formed this opinion from the study of the slates simply, and from some reasoning as to what might be looked for as a result of disintegration of granites and other rocks, Pfaff bases his verdict more on the fact that he has studied *clays* of various ages (including Carboniferous, Triassic, Jurassic, and Tertiary), in all of which he sees the microlites (rutile) and the micaceous base, as in the slates.

If the result of a full study of clays and shales were to convince the observer that the rutile, etc., and the micaceous base are all *original* deposit, then the very great similarity in these respects of clays and slates would go far to compel the adoption of the same conclusions as are advocated by Sorby and Pfaff.

As shown above, the key lies in the selection for study of clays whose exact and *direct* origin can be pretty clearly demonstrated. In such clays I do not consider it is possible, in view of all the characteristics, to look on the rutile, tourmaline, mica, etc., as of clastic origin.

Pfaff's paper is abstracted and criticized by Rosenbusch (Neues Jahrbuch für Min. etc., 1881), who expresses very decidedly contrary opinions to those of Pfaff, stating that he holds the *cardinal point* as to the question of the formation of slates to lie in the large amount of mica, from which he concludes that chemical processes have played a large part. "Gewiss wurde das Material zu den Thonschiefern mechanisch herbeigeführt, der Mineralbestand aber der vorwiegend glimmerhaltigen und felspathfreien Abtheilung derselben ist gewiss durch metamorphe Processe bedingt."

In dealing with the same question on a previous occasion (Die Steiger Schiefer,

as President of the Geological Society in 1880 (Q.J.G.S. vol. xxxvi.) stated that, though he had at first looked upon this mica as secondary, he was finally of opinion that the main micaceous constituent of the Welsh slates—the mass of small flakes lying parallel to the cleavage—is not secondary, but is simply the compacted material of the original deposit. Dr. Sorby stated that he considered that the mica of granites, etc., "except in special cases, where much iron is present," is not liable to fall to pieces by weathering so as to yield the small flakes seen in slates. He looks upon this small mica as derived from fine-grained micaceous felsites, whereas "coarse-grained granites and felspathic felsites, even when very micaceous, could yield only kaolinitic clays."

"Deposits mainly composed of inert substances like quartz, mica, and kaoline, can undergo little further change," though he considers that felspar may decompose after deposit, giving rise to quartz and opal. He admits that the crystals of mica which are not parallel to the cleavage, "but lie at all possible azimuths," are of new formation, but says that as regards the rest of it "the whole structure is, in fact, just such as would result from the deposition of material sorted by gentle currents and subsequently compressed, vertically by pressure of overlying strata, or laterally by that which gave rise to slaty cleavage."

Dr. Sorby does not lay any stress on the remarkable diffusion of rutile crystals in so many slates; indeed, in the paper above quoted, he does not do more than indirectly allude to them. At the time he wrote the paper, the nature of the minuter "clay-slate needles" as rutile was only just about being established.[1] Had he taken the rutile into consideration, it is difficult to see how he would have explained in such cases its presence in simply compacted original mica from felsites, as the mica of these rocks does not usually contain rutile.

I think the opinion that the mica of granites would not yield a fine-grained deposit is not borne out by the study of the clays and shales of granitic origin; coarse-grained and fine-grained layers of

1877, pp. 116–118), though he was very positive as to the non-admissibility of the clastic origin of the rutiles, tourmalines, etc., of the slates, he was much more reserved in any expression of opinion as to the mica.

Rénard also, who has so deeply studied the slates of the Ardennes, appears to have arrived at views quite opposed to the idea of such rocks being simply compacted original sediments (*op. cit.*).

[1] The first decided proof that these needles are rutile was given by Cathrein ("Ein Beitrag zur Kenntniss der Wildschönauer Schiefer und der Thonschiefernädelchen," Neues Jahrbuch für Min. Geologie, etc., 1881).

In dealing with his method of isolation of the rutile, Cathrein mentions the "roundish grains" as well as crystals, and looks on these as "partly imperfectly developed rutile needles."

Very soon after Cathrein's paper, in the same year, an article appeared in the "Neues Jahrbuch" by Dr. Sauer ("Rutil als mikroskopischer Gemengtheil in der Gneiss- und Glimmerformation, sowie als Thonschiefernädelchen in der Phyllitformation"), in which the proof of the nature of the slate-needles is again fully carried out; and a note by Prof. Rosenbusch states that Sauer had communicated the contents of this article to him in private correspondence before the appearance of Cathrein's paper.

all thicknesses alternate abruptly or gradually, according as the conditions of deposit changed, in so many beds which had the same origin throughout so far as we can see.

I hope I have also succeeded in showing that deposits of the waste of granitic rocks by no means consist of inert substances that could not readily undergo further change, but that, on the contrary, they are very active indeed in such changes.

It must be borne in mind, as Dr. Sorby points out, that it is more than likely that in many slates we have the result of deposits from more than one source of material at the same time; also that they may be produced from *different* sources without such mixture. Further, that the exact nature of slates is liable to vary very considerably even in adjacent laminæ, or in the same laminæ at different parts, so that care must be taken not to draw too decided conclusions from one or two observations.

In considering the nature of the mica, it is to be recollected that some of these slates probably contain more or less of the waste of still older slates of similar nature, which waste would mainly consist of rutiliferous mica. Flakes of white, or almost white mica, with the rutile inclosures, form a prominent constituent of some silts and muds now being deposited, and of some surface clays. This, however, would not much affect the question of the *first* origin of the rutiliferous mica, and we may reasonably suppose that in the early geological periods, to which the slates now specially under discussion belong, there would be less and less probability of previous slates supplying part of the material. Of course, if my contention is correct, that many of the slates resulted from alteration of sediments from granite, more or less rich in biotite, and that these sediments were exactly similar in nature, and underwent just the same processes of change as we can see in the deposits of the Coal-measures, it is not in any way suggested that the *conditions* of deposit were the same. These may have varied to any extent as to depth of water, currents, etc., etc., but the conditions of denudation would be more or less the same, and also the nature of the finally deposited sediment.

Shales, slates, and sandstones pass into one another by all degrees of transition. Many sandstones, especially those of fine grain, have as "cement" the same material which forms the "paste" in the clays and shales above described, and frequently between the grains of quartz we see films of just the same micaceous and rutiliferous alteration-product. Mr. J. A. Phillips (Q.J.G.S. vol. xxxvii.) seems to have observed this in some cases. Thus he says (May Hill Sandstone) that the grains are "cemented together by a turbid siliceous cement, suggesting the idea of its having been deposited from water holding clay in suspension"; and again (Sandstone from Brigham in Cumberland) he speaks of this cloudy cement and says, "Between the fragments of this rock there are sometimes minute crystals of a mineral which may be epidote."

REVIEWS.

I.—Le rocce eruttive dell' Eocene superiore nell' Apennino. By Prof. de Carlo Stefani. Boll. Soc. geol. Ital. VIII. No. 2, 1889.

THE Eocene eruptive rocks of Northern Italy have already acquired a somewhat extensive literature. The last addition to this is the above-cited memoir, which fully sustains its author's reputation for viewing petrological subjects from an advanced standpoint. The memoir is therefore of value, not only as a contribution to the study of some local rocks, but as a pronouncement on the part of a leading Italian geologist on some of the broader geological problems connected with them. English geologists especially will be interested in the expression of such views as "it is wrong to give distinct names to rocks in their altered conditions" (p. 262), or that "from the point of view of lithology, it may be affirmed, in contradiction to the teaching of my masters, that the ancient eruptive rocks are identical with the modern" (p. 262). Prof. Stefani has previously expressed similar views, but they have probably never before been so definitely asserted by any Italian geologist.

The memoir commences with a useful bibliography, and is divided into nine sections. The first deals with the nature, mode of origin, and correlation of the beds with which the igneous rocks are associated: a full list of fossils is quoted, and a short sketch given of the work by which the old view of the submarine volcanic age of the deposits has been disproved. The author maintains instead that they are really normal deep-sea deposits.

The igneous rocks are described in the next five sections; their origin discussed in the seventh; the eighth and ninth are devoted to their stratigraphical relations and distribution, and a summary of the author's opinions concludes the memoir.

§ 2. *The Peridotites.*—The most important of these is a mixture of olivine and enstatite, for which Wadsworth's name of saxonite, though admittedly a misnomer, is preferred to the later name of "harzburgite" (Rosenbusch). The occasional presence of diallage as at Levanto (Bonney), and at Pria Borgheise (Mattirolo), indicates an approach to lherzolite; but the author regards the diallage in these cases as always accessory, and hence declines to accept the rocks as true lherzolites, though Rosenbusch has so named the rock of the latter locality. In other cases the presence of augite suggests a passage to picrite (of Rosenbusch), while in places the scarcity of enstatite leaves the rock as a kind of "dunite." The author denies the occurrence of "wehrlite" on Monte Prato.

The serpentines have always, according to Prof. Stefani, resulted from the alteration of saxonite. In supporting this conclusion he dismisses the following hypotheses of the formation of serpentine: (1) from argillaceous schist, advanced by Achiardi in 1874, a view based on superficial resemblances; (2) from diallage, as urged by Berwerth for that of Rosignano, in consequence of his having

mistaken the bastite and enstatite for diallage; (3) from enstatite or other pyroxene in cases where there seems no trace of olivine (Cossa); (4) a theory attributed to (but already promptly repudiated by) Mazzuoli of the formation of olivine, etc., by the dehydration of serpentine. Finally, the author does not regard as reliable the method proposed by Hussak for distinguishing serpentines formed from rhombic pyroxenes from those formed from olivine (p. 196).

§ 3. *The Gabbro.*—This term is adopted instead of euphotide, which has been much used by Italian geologists owing to the misapplication of the former by Savi. A petrosilex or forellenstein is formed locally by the segregation of the labradorite, and a diallagite by that of the pyroxene. The gabbro is also at places altered to "thulite" by the loss of silica and addition of magnesia. There are many alteration products present, including some serpentine; but this the author regards as indicating that the rock was there an olivine gabbro, rather than the formation of the serpentine from diallage.

Norites have been quoted from the district only owing to the diallage having been mistaken for hypersthene.

§ 4. Diabase is extremely abundant; amygdaloidal and variolitic structures are common; in opposition to the opinion of Rosenbusch, Gumbel, etc., the author does not regard the latter as a mere contact phenomenon. True diorite does not occur, but the uralitization of the augite is often so complete that it is then almost impossible, as at Riparbella, to be certain that the rock is really an epidiorite.

§ 5. A soda granite is fairly widely distributed in Emilio and Liguria di Levante, and this Prof. Stefani regards as having probably been a liparite.

§ 6. Certain diabases and serpentine breccias have been previously described, as *e.g.* by Prof. Bonney from Levanto. These the author regards as "tuffs" analogous to those that accompany the "kimberleyite" of S. Africa, and the picrites of the Fichtelgebirge. Sometimes, as Mulino di Villa, the tuffs include diabase fragments with variolitic surfaces; Prof. Stefani regards these crusts as due to the decomposition of the diabase, though it may be suggested that they are really variolitic tuffs like those simultaneously described from Mont Genèvre. Similarly the rock from Levanto, re-described as an "ophicalcite tuff," seems very much like the rock from Mont Genèvre, regarded as a serpentine breccia.

§ 7. In discussing the eruptive origin of the rocks, the author lays much stress on the salbands, which he regards as conclusive in the case of the diabase. Much value is also attributed to the amygdaloidal and porphyritic structures. The other theories, such as Mazzuoli and Issel's "anfimorphic" hypothesis (that the serpentines have resulted from the alteration of a hot, submarine mud), and Taramelli's view of the formation of the same rock as a precipitate in a hot sea, are examined and dismissed. Prof. Stefani claims that all the rocks are eruptive, and that the coarseness of grain of the gabbro is due to its having arisen as an outpouring on the floor of a deep ocean and having solidified under the enormous pressure of

the superincumbent water. He further compares the rocks with those of other ages, from the prepalæozoic downward, and is very emphatic as to the impossibility of using age as a character in any natural or logical classification.

§ 8. The relations of the rocks to the sedimentary deposits. Prof. Stefani proved in 1876 that the serpentine of Garfagna was regularly interstratified in the Upper Eocene; this has been supported by Taramelli, and may be regarded as a type case. Sterry Hunt's view that the serpentines are part of a prepalæozic floor exposed at places by denudation, etc., is very summarily dismissed: "It is the opinion of one, who either does not observe facts or, who having observed them, gives more weight to his own conceits than to these." The author has discussed this hypothesis once before, and does not seem to deem it necessary to repeat the process.

§ 9. The most important point established in the section on distribution is that there is as a rule a fairly constant succession; the peridotites were the earliest, the gabbros followed, and the diabases concluded the series. But in places diabase occurs intercalated in either the peridotite or gabbro, and these with other exceptions show that the rule is not absolute.

In conclusion, the author refers to the extension of similar eruptive rocks of the same age, along the northern coast of the Mediterranean; these can be traced in Spain, Switzerland, Dalmatia, and through Bosnia and Herzegovina, as far south as Eubœa. The opinion is advanced that in late Eocene times, these rocks were erupted from a series of volcanoes, often submarine, that encircled the northern margin of a very deep sea, just as the Malayasian volcanoes extend along the northern margin of a deep part of the Pacific.

Though many geologists will probably require further evidence before accepting some of the author's conclusions, such as that the division into plutonic and volcanic is fundamentally erroneous, that the gabbros are eruptive, or that the "serpentine breccias" are "tuffs," they cannot but be grateful to Prof. Stefani for so valuable a contribution to so interesting a group of rocks, and will await with interest the promised publication of the issues of his further investigations. J. W. G.

II.—The Genesis of the Arietidæ. By Professor Alpheus Hyatt. Smithsonian Contributions to Knowledge, 673. 4to. pages vii–xi, 1–223; 14 Plates and 35 Woodcuts. (Washington, 1889.)

THE handling of a collection rich not only in species but in all possible varieties and abnormal forms, and access to the literature upon the subject, are important factors in genealogic investigations. Such opportunities has Prof. Hyatt enjoyed, and his latest work just to hand is another proof that he has turned them to the best possible account.

Since 1867 Prof. Hyatt has given to the world a most valuable series of pamphlets concerning the genealogy and classification of

Jurassic Ammonites, as well as of Cephalopoda generally; and the important and valuable monograph now before us treats not only of the genesis, but also of the entire specific evolution of the grand Liassic Ammonite family, the Arietidæ. Not the least important feature of the work is that it is illustrated by fourteen excellent plates prepared expressly to show the developmental changes and the genealogy of the various species.

The principles of Ammonite development, which, we believe, owe to Prof. Hyatt their first enunciation and application, though they have also been put forward by other workers independently, are, in the present work, fully discussed in two long chapters. "Genealogy" and the "Genesis of Characteristics" are treated in two other chapters; on "Geological and Faunal Relations" is the title of a chapter discussing the birthplaces and migrations of the different series; and then lastly follows a chapter describing the genera and species.

With the main results of Prof. Hyatt's labours we find ourselves in complete accord; but we might be inclined to criticize some of his genealogic conclusions. We are, however, disposed to be cautious in this matter, as we have not the number of specimens to appeal to.

Still it seems to us that to trace the Arietidæ to *Psiloceras planorbe* may be a mistake. This species we regard—on account of the ribs in the inner whorls and its slightly more involute form—as a smooth development of *Am. Johnstoni*, and not the ancestor thereof. That *Am. Johnstoni* and the Arietidæ were derived from a very evolute, perfectly smooth form, and that this was derived from an involute, gibbous-whorled, smooth form—a shell more evolute than *Nannites fugax* and more involute than *Agassiceras lævigatum*, something like *N. fugax* being the ancestor producing forms similar to *Ag. lævigatum* and *Am. miserabile* as it became more and more evolute—seems to be indicated by the inner whorls of species which we have broken up.

However, space does not allow us to discuss this and certain other points; but we wish to say that this work has given us extreme pleasure, and that we cordially congratulate the talented author upon the splendid results which this monograph lays before us—results which indicate a vast amount of careful and critical research. Not only is a study of this monograph absolutely essential to the student of Ammonites, or of Cephalopoda; but it is quite as necessary to the student of Lamellibranchiata, Gasteropoda, etc., because the same principles of development hold good.

One little matter we feel bound to mention. We dislike to see well-known species like *Am. planorbis*, Sowerby, written as "*Psiloceras planorbe*, Hyatt." This method was condemned by a committee of celebrated naturalists in 1842,[1] and the practice of European authors who write "*Psiloceras planorbe* (Sowerby)," or "Sowerby sp." sufficiently supports their decision. S. S. B.

[1] On Zoological Nomenclature, Report British Assoc. vol. xi. See also Rapport du Commission du Congrès international, Paris, 1881, p. 4.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 21, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Devonian and Silurian Ostracoda from North America, France, and the Bosphorus. By Prof. T. Rupert Jones, F.R.S., F.G.S.

Of the Devonian species herein figured and described, six species and one variety (four being new) from the decomposed Chert of the Corniferous Limestone of Ontario County, in the State of New York, and new species from the Hamilton Group of Clarke Co., Indiana, have been sent by Mr. J. M. Clarke, of Albany, N.Y., as mentioned in the February number of the Quart. Journ. Geol. Soc. p. 14. From Eighteen-mile Creek, Lake Erie, N.Y., there are two new Devonian species among specimens supplied by Dr. Hinde (*op. cit.* p. 28), and two new *Primitiæ* from Thedford. Altogether five genera (*Bollia*, J. & H., *Moorea*, J. & K., *Octonaria*, J., *Eurychilina*, Ulrich, and *Ulrichia*, gen. nov.) are hereby added to the list of "Hamilton" fossils.

The Devonian *Beyrichia* collected some years ago by M. Dumont at the Bosphorus, and noticed by Dr. Ferd. Römer in the 'Neues Jahrbuch' for 1863, having been kindly lent by M. Dewalque for examination, is figured and described in detail. It appears to be the same as *B. devonica*, Jones, lately described from Devonshire.

Nine new species from Anticosti, in Dr. Hinde's collection, alluded to above, are here figured and described. They are from Mr. Billings's "Anticosti Group" (Divisions 3, 2, 1, and the lowest). The lowest and Div. 1 are both now regarded as of Lower Silurian age, and Divs. 2 and 3 are either Middle or Upper Silurian. A series of Silurian Ostracoda from Canada, submitted by Mr. Whiteaves, F.G.S., and Mr. Ami, F.G.S., have been examined, and critical notes on them are here given.

The Lower-Silurian *Beyrichia Guilleri*, named and compared with other species by M. G. de Tromelin at Nantes in 1875, who found it at Domfront and elsewhere in Brittany, is also figured and described in detail.

2. "On the Age, Composition, and Structure of the Plateau-gravels of East Berkshire and West Surrey." By the Rev. A. Irving, B.A., D.Sc., F.G.S.

The author refers to the view propounded by him somewhat tentatively seven years ago, and since confirmed by the researches of Prof. Prestwich, as to the Preglacial age (probably Pliocene) of these deposits, pointing out the inconclusive nature of the evidence of Glacial age furnished by the presence in them of angular "sarsens." He regards the absence of Miocene marine deposits in this part of North-western Europe as supporting the published view of Zittel and other continental writers that the Miocene period was, in South-eastern England, one of elevation and subaerial waste and

degradation of the Weald to the south, and of East-Mercian England to the north-west, this period of waste of the Cretaceous rocks having furnished much of the materials which, in Pliocene times, were carried across a sloping plateau by fluviatile agencies.

The composition and structure of the plateau-gravels are next described, reference being made to previous writings of Prof. Rupert Jones and to the recent papers of Prof. Prestwich. Reference is also made to the explanation suggested by the author seven years ago of the anomalous contrast presented by the lithological conditions of the flint-pebbles and the subangular flint-fragments which are intermingled in these gravels. The great masses of unstratified and unrolled flint débris on the Aldershot Hills are compared with the Preglacial "Schotter" of the lower Alpine valleys. The plateau-gravels are described as occupying altitudes ranging from nearly 600′ (O.D.) at Aldershot and on the north side of Netley Heath, down to 280′ (O.D.) at Bearwood and Farley Hill. A list of 22 localities (with altitudes) is given where actual sections of the plateau-gravels can be studied.

Evidence of glacial action at lower levels (210′ to 240′ O.D.) is then given, sections being described at Nine-mile Ride (Old Windsor Forest), Wokingham, and Sunninghill, and apparent evidence of glaciation at Bracknell, Warfield, and Finchampstead. Photographs of some of these sections are given, and the levels of the plateau-gravels and the glaciated sections correlated by a sectional diagram.

The author concludes, from the evidence given in the paper, that:

1. The Plateau-gravels are of fluviatile origin, their materials having been transported from the Weald-region to the south.

2. They mark roughly the ancient lines of Pliocene drainage of an old elevated Tertiary region, the present valley-system having been mainly determined by their absence.

3. That the modern Lower Thames Valley was initiated in Pliocene times, the main line of drainage having been somewhat further north than at present.

4. That attention to altitudes reveals the fact that the present valley-system was outlined and the major part of it actually excavated in an interval that intervened between the age of the Plateau-gravels and the Glacial Epoch.

5. That the deposition of the Plateau-gravels probably covers most of the geologic time represented by the Pliocene.

A note is added on the probable progressive elevation of the Weald from west to east.

3. "Further Note on the Existence of Triassic Rocks in the English Channel off the Coast of Cornwall." By R. N. Worth, Esq., F.G.S.

A specimen of Triassic conglomerate trawled seven miles south of the Deadman headland, and several miles east of the previously recorded Lizard outlier, is described, and reasons given for its occurrence *in situ*. It contains pebbles of slate, grits, vein-quartz, quartz-felsite, and andesitic rock.

4. "On a New Species of *Coccodus* (*C. Lindströmi*, Davis)." By J. W. Davis, Esq., F.G.S.

A description is given of a small fossil fish from the hard chalk of Hakel in Mount Lebanon; it is nearly related to *Coccodus armatus*, Pictet, but is smaller than that species, does not show an equivalent of the pectoral spine (unless the posterior extension of the scapular arch should be so considered), and the posterior basal extension of the dorsal spine is very different in the two forms. Further, the dorsal spine is nearer to the occipital region in the new form than in *C. armatus*, and is, compared with the size of the fish, a larger fin.

The arrangement of the fins shown in the specimen now described is quite different to that of the Siluroids (*Synodontis* and *Pimelodus*), and the great resemblance of the teeth of *Coccodus* to those of the Pycnodonts, and the cartilaginous character of the vertebræ, indicate a relationship with the Ganoids; but its exact relationship in that group must remain still problematical.

The author proposes to name the new form *Coccodus Lindströmi*.

II.—June 4, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.

The PRESIDENT referred to the sad loss which the Society had sustained through the death of Mr. Dallas, and read the following resolution, which had been passed by the Council and ordered to be entered upon its Minutes:—

> "The Council desires to record on its Minutes an expression of its deep regret at the death of the Assistant-Secretary, Mr. Dallas, which took place on the 29th ultimo, and of its sense of the loss inflicted on the Council and Society by the removal of one who, for the long period of twenty-two years, had done them invaluable service, and who, by his courtesy, kindliness, and helpfulness had endeared himself as a personal friend to the Fellows."

It was moved by Dr. EVANS, seconded by Dr. HINDE, and carried unanimously, that the resolution passed by the Council be communicated to Mrs. Dallas on behalf of the Society also. (See Obituary, p. 333.)

The following communications were read:—

1. "As to certain 'Changes of Level' along the Shores on the Western Side of Italy." By R. Mackley Browne, Esq., F.G.S.

After noticing the prevailing opinion that such changes as he treats of were caused by earth-movements of elevation and depression, the author suggests that the altered levels were due to altered conditions of the Mediterranean. He brings forward objections to the prevailing theory, and remarks on the possibility of periodical oscillating alterations in the tidal depth of the ocean.

After noticing the special characteristics of the Mediterranean, he infers that submergence and emergence on the Bay of Baiae would follow equivalent alteration in the level of the Atlantic waters, such as would be probably developed by changed conditions of astronomical forces; and after discussing the possible dates and periods of the changes at Pozzuoli, makes the suggestion that within a period of two thousand years alterations may have taken place in the astronomical combinations, out of which a change in the surface-level of the oceans generally may have become developed, and wherefrom consequently a synchronous change in the Mediterranean would also occur, and observes that the amount of actual tidal effects has never been ascertained.

2. "North-Italian Bryozoa." By A. W. Waters, Esq., F.G.S.

The Chilostomatous Bryozoa dealt with in the paper are, for the most part, from known Vicentine localities, together with some from two new localities,—Monte Baldo in the Veronese and Ronzo in the Tyrol. Reuss described a number from the Vicentine, but at a time when the chief attention was given to the shape of the zoarium, and the oral aperture, avicularia, and ovicells did not receive the attention now given to them. The attempt is therefore made to bring our knowledge of these beds, which are the richest and most important known in the Lower Tertiaries, more nearly up to present ideas, so that more exact comparisons may be made between Tertiary and living forms.

Several cases are mentioned in which there is great difference of zoarial shape, and also some in which there is great range in the zoœcial characters.

The discovery of *Catenicella* in these beds is of considerable importance, which is enhanced by one of the species having both short beads and longer internodes.

Porina coronata and *Lepralia syringopora* both have a closure, formed by a plate with a tubule in the centre, a structure supposed to be exclusively characteristic of the Cyclostomata.

The position of the beds has been established by Suess, Bayan, Hébert, and Munier-Chalmas, of Bartonian age, and may therefore be called Upper Eocene.

3. "Notes on the Discovery, Mode of Occurrence, and Distribution of the Nickel-Iron Alloy 'Awaruite' and the Rocks of the District on the West Coast of the South Island of New Zealand in which it is found." By Professor G. H. F. Ulrich, F.G.S.

In an introduction the author describes the original discovery, determination, and naming of the mineral in 1885 by Mr. W. Skey, and clears up a misunderstanding by which he himself had been credited with the discovery; he furthermore gives a historical sketch of the further investigations and publications referring to the mineral.

The geology of the Awaruite-bearing district is described. The rocks consist of peridotites and serpentines, breaking through metamorphic schists with occasional massive intrusions of acid rock. The petrographical characters of the peridotites of the hill-complex, including the Olivine and Red-Hill ranges, and serpentines, are con-

sidered in detail, and the mode of occurrence of the Awaruite in them and in the sands derived from their denudation is discussed. The author submits a sketch-map of the localities where the mineral has been discovered in sand, including not only George River, but also Silver Creek, Red Hill, and other localities, and quotes Mr. Paulin's belief that it occurs diffused through the whole extent of peridotite and serpentine rocks, and inferentially in the drifts derived therefrom.

OBITUARY.

JOHN GUNN, M.A., F.G.S.,

FORMERLY RECTOR OF IRSTEAD AND BARTON TURF, IN NORFOLK.

BORN OCTOBER 9TH, 1801; DIED MAY 28TH, 1890.

BY the death of Mr. John Gunn, geological science has lost one of her most devoted and enthusiastic disciples. Born October 9th, 1801, he lived to the advanced age of 88, and was thus one of the last links between the geologists of the present day and those who laid the foundations of the science.

His father, the Rev. William Gunn, Rector of Irstead and Barton Turf, in Norfolk, was a man of considerable literary attainments, and more especially devoted to History and Archæology, but taking very little interest in the pursuit of Natural Science.

In an address delivered to the Norwich Geological Society in 1869, John Gunn thus speaks of his early years:—"When at school he was more interested in Natural History than in the Latin Grammar, and his father put the books he was most anxious to study at the top of the library, so that they might be out of his reach. He, however, took every convenient opportunity to get at a volume of Buffon, and thus he gathered some knowledge respecting the habits and the habitat of animals. He could never forget, and he could not describe the electric effect produced upon him by the discovery of the fossil remains of the Elephant, Rhinoceros, and Hippopotamus in the Forest Bed at Happisburgh, etc. He then asked his father how these creatures, now living in tropical countries, could have existed in this? And he received an answer which was still fresh in his memory, and which constantly recurred to him. 'There is much to be done before that can be made out.'"[1] This question probably was put about the year 1822, when R. C. Taylor published his account of Fossil Bones on the Coast of East Norfolk. It must have been soon after this date that John Gunn made the acquaintance of Samuel Woodward, from whom he derived his earliest lessons in geology; moreover his local researches were no doubt stimulated by intercourse with his neighbours, the Rev. James Layton, of Catfield, and Miss Anna Gurney, of North Repps, both of whom became ardent collectors of the fossil mammalia from the Forest Bed.

On the death of his father in 1841, John Gunn, who had been

[1] "Norwich Mercury," Feb. 10, 1869.

Chaplain to H.R.H. the Duke of Sussex, was appointed to the rectory, and for many years his home was at Irstead.

By his marriage with Harriet, a daughter of Dawson Turner, F.R.S., of Yarmouth, he became brother-in-law of Sir W. J. Hooker, and Sir Francis Palgrave. Mrs. Gunn was a talented artist, and accompanied her husband over many parts of Norfolk, their attention being in early years mainly given to archæological studies; geological subjects, however, in turn, attracted attention, and we find in Lyell's "Elements of Geology" an illustration of the Chalk-pit at Horstead, with its paramoudras, from a drawing made by Mrs. Gunn in 1838.

From about the year 1850 until the close of his life, John Gunn's energies were very largely devoted to geology, and in particular to the vertebrate remains of the Forest Bed. He gathered together a very fine collection of the fossils, which he presented in 1868 to the Norfolk and Norwich Museum.

His observations on the geology of Norfolk were brought together in a Sketch, published in 1864, in White's History and Directory of the County. A fourth edition of this article, which was reprinted for private circulation, was issued in 1883, and it was Mr. Gunn's intention to publish the same in a separate and extended form, a task in which he had been diligently engaged to within a few months of his death.

Mr. Gunn took an active part in the formation of the Norfolk Archæological Society. In April, 1864, the Norwich Geological Society was founded, Mr. Gunn being elected President, and Mr. J. E. Taylor, Secretary. Until 1878, the reports of the meetings were published in the local newspapers, but a summary of these (with references) was printed in the first part of the "Proceedings" of the Society commenced in 1878.[1] During this period Mr. Gunn contributed frequent accounts of recent discoveries, and also remarks on various subjects, more especially dealing with the Mammaliferous Stone-bed at the base of the Norwich Crag, the relations of the Norwich Crag and Forest Bed to the Chillesford Clay, and the prospect of finding productive Coal-measures in Norfolk and Suffolk. Many excursions were made by the Society to different parts of the county, and at the annual meetings an account of what had been done during the year was given by the President.

Mr. Gunn also contributed an occasional paper to the Geological Society of London, and to the Geologists' Association. While, however, he was always ready and rejoiced to take up the hammer and go into the field, and to communicate all his information to others, he manifested no great eagerness to publish. Thus it has been that much of his work is embodied in the writings of others, who have acknowledged their indebtedness to him. The recognition of an Upper and Lower Boulder Clay, separated by a mass of sand, to be seen on the coast near Yarmouth and Lowestoft, was due to Mr. Gunn, but published (with acknowledgment) by Joshua

[1] Only one volume has been published, 1878–84; the Society is now merged with the Norfolk and Norwich Naturalists' Society.

Trimmer.[1] The distinction between the Post-Glacial Mundesley River-bed and the older Forest Bed Series was first perceived by Mr. Gunn.[2] His collection of fossil mammalia, and especially the specimens of Elephant, proved of much service to Falconer and Leith Adams; the former remarks that "The interest and value of his collection are only equalled by the liberality with which he makes it available for the ends of science. I need only say in illustration that he has placed all the specimens in his possession at my disposal for this essay, even to be sawn up for sections, if necessary, or for any other use to which they could be turned."[3]

Mr. Gunn's enthusiasm may be well realized when it is remembered that (in 1888) when 87 years of age, he attended the London meeting of the International Geological Congress, and subsequently paid a visit to St. Erth, in Cornwall, to examine the Pliocene Beds that have been discovered in that neighbourhood.

Notwithstanding his devotion to geology, Mr. Gunn, while rector of Irstead, was very energetic in the pursuit of his clerical duties, and filled the position of Rural Dean.

In 1869, after forty years' service in the Church, he resigned his preferment, and ultimately quitted the ministry. This he did because he became convinced that he could no longer conscientiously preach some of the doctrines of the Church of England. In his published letter to his parishioners, he remarks: "It was a hard wrench for me to part from the place of my birth, the scenes of childhood, and of a mature and happy life; from a charming spot where almost every tree and shrub had been planted by myself; and, above all, from parishioners between whom and myself there ever had subsisted a most cordial feeling of good will."

Mr. Gunn died May 28th, 1890, and was buried at the Rosary, Norwich.

WILLIAM SWEETLAND DALLAS, F.L.S.

Born 31st January, 1824; Died 29th May, 1890.

It is with deep regret we have to record the death of Mr. W. S. Dallas, the able and accomplished Assistant-Secretary of the Geological Society of London; a man universally esteemed and beloved by all, and one whose loss to science it will be difficult to supply.

William Sweetland Dallas was the youngest son of Mr. William Dallas, belonging to an ancient Scottish family, an East India Merchant and a Member of Lloyds', who died in 1842.

Born in Islington, January 31st, 1824, he early evinced a love of Natural History, and when only a boy made collections of Insects with his elder brother in the fields of Hampstead, Highgate, and Hornsey.

[1] See J. H. Blake, Geol. Yarmouth and Lowestoft (Geol. Surv.), p. 28.
[2] Lyell, Antiq. Man, Fourth Edition, p. 267.
[3] Quart. Journ. Geol. Soc. vol. xxi. p. 299. See also E. T. Newton, Vertebrata of the Forest Bed Series, 1882.

He was educated at University College School, where he attained a thorough grounding in Classics, in which he afterwards displayed so great a proficiency. In later years he devoted himself to the mastering of French, German, and Italian, with marked success; and still later, to the acquisition of a knowledge of Danish, Swedish, and Norwegian.

His father failed when William was only twelve years of age, and his elder brothers, John and James Dallas, had both to abandon their prospect of a profession and enter business houses in the City. William, on his leaving school, was also taken into Mr. Milne's office; but City life was so very distasteful to him, that he relinquished it and commenced to study in the old Reading-Room of the British Museum. Here his strong passion for the pursuit of Entomology was allowed to dominate all else for a time, and so eager was the young naturalist to possess a library of his own, that he not only copied out large parts of various descriptive works on his favourite science, but even went so far as to transcribe in neat handwriting the whole text of J. Chris. Fabricius's "Entomologia Systematica" (Tome I. to IV. 8vo. Hafniæ, 1792)—a work of 2677 pages octavo—to each generic description of which he added a coloured figure of the type-species, copied from a specimen, or from some other work.[1]

His devotion to Natural History, and especially to the collecting and preserving of Insects, attracted young Dallas to the Insect-room at the British Museum, where, in the late Dr. John Edward Gray, F.R.S., he found a warm friend and supporter.

In 1847 he commenced to contribute original papers to the Entomological Society of London, which duly appeared in its Transactions from that year to 1853.

In 1849 Mr. W. S. Dallas was elected a Fellow of the Linnæan Society, and in the year following he married Miss Frances Esther Price, youngest child of Liscombe Price, Esq., of London and Abergavenny (one of the lawyers employed in the trial of Queen Caroline).

From 1850 to 1852 Mr. Dallas was engaged in preparing Lists of the Hemipterous Insects in the British Museum.

Immediately on the erection of the Crystal Palace, Sydenham, Mr. Dallas was engaged by the Committee to arrange the Natural History collections in that building.

From 1854 to the end of 1855 Mr. Dallas contributed 28 chapters on Zoology to Orr's "Circle of the Sciences." These were afterwards reprinted as a separate work, in 1856, entitled "A Natural History of the Animal Kingdom."

In 1857 he completed his "Elements of Entomology; an Outline of the Natural History and Classification of British Insects," 8vo. pp. 424, published by Van Voorst.

In 1858, on the resignation of Mr. Edward Charlesworth, F.G.S.,

[1] Of W. S. Dallas's brothers, only the second, Elmslie W. Dallas, appears to have taken up a scientific career. He settled in Edinburgh, and became an artist of some repute, was author of a work on Mathematics, and was elected a Fellow of the Royal Society of Edinburgh.

Mr. W. S. Dallas was appointed Curator of the Yorkshire Philosophical Society's Museum in York, a post which had been, at an earlier date, filled by the late Professor Phillips, F.R.S. (of Oxford). Here he resided with his family, now numbering four sons and two daughters, until the close of 1868.

His life at York, apart from the Museum, was taken up largely with writing for the "Westminster Review," and the preparation of translations of papers for the "Annals" and the "Philosophical Magazine." Mr. Dallas also served, for some years, as one of the staff engaged in the preparation of the "Zoological Record." He was Hon. Sec. of the Yorkshire Naturalists' Club from 1859 to 1869; and, through his friendship with Mr. George Tate, of Alnwick, he was appointed to give a course of lectures each summer to the school maintained by His Grace the Duke of Northumberland in Alnwick; these lectures were most popular and were always attended by their Graces and the neighbouring families.

On the retirement of Mr. H. M. Jenkins, F.G.S., M. Dallas was elected Assistant-Secretary to the Geological Society of London, an office which he held, greatly to the benefit of the Society, until his death in May last.

Mr. Dallas was Editor of the "Annals and Magazine of Natural History" from 1868 to 1890; he was also Editor of the "Popular Science Review" from 1877 to 1880.

Paralysis, of which he had had premonitory symptoms, terminated his laborious life on the morning of 29th May, in his 67th year.

In taking a retrospect of Mr. W. S. Dallas's useful but arduous career, one is astonished at the vast amount of important work achieved by him and the small share of recognition which it fell to his lot to receive. But a glance at the nature of that work will suffice to show that by far the largest and most laborious part was occupied by him either as a Curator, an Editor, a Journalist, or as a Translator, in all of which capacities—however well the duties may have been performed—the *κῦδος* is but small.

Mr. Dallas was moreover a man of very retiring habits, yet he enjoyed the warm friendship and regard of John Edward Gray, of Charles Darwin, of Sir Charles Lyell, Prof. Sir Richard Owen, of Geo. R. Waterhouse, of Huxley, S. P. Woodward, Bates and Wallace, T. Rupert Jones, and many other of the older naturalists. He frequently acted as *collaborateur* to Darwin, and indexed his works for him with that loving care which only strong personal attachment could have brought to the task. The writer well remembers the words of Prof. Huxley when commending him to the Council of the Geological Society for the post which he held till his death: "Mr. Dallas is one of the hardest workers that I know." To those who knew him intimately Mr. Dallas will also be remembered for the gentleness and amiability of his disposition, his rare modesty, and for his uniform courtesy to all.

Works, papers, and translations, by William Sweetland Dallas, F.L.S.

A List of the Hemipterous Insects in the Collection of the British Museum. Part i. pp. 368, 11 plates. 1851. Part ii. pp. 369–590, pl. 12–15. 1852.

"A Natural History of the Animal Kingdom, being a Systematic and Popular Description of the Habits, Structure and Classification of Animals from the Lowest to the Highest Forms, arranged according to their Organization." London, 1856. 8vo. pp. 818, and 374 woodcuts (originally issued as a series of articles in Orr's "Circle of the Sciences," where it appeared in 28 parts, from 1854 to 1855).

Elements of Entomology: an Outline of the Natural History and Classification of British Insects. London, 1857. 8vo. pp. 424. (Van Voorst.)

Sketch of the Genus *Pœcilocoris*, belonging to the Hemipterous Family *Scutelleridæ*. Entomological Society's Transactions, v. 1847–9, pp. 100–109.

Notice of some Hemipterous Insects from Boutan (in the Collection of the Hon. East India Company), with Descriptions of the New Species. Entom. Soc. Trans. v. 1847–1849, pp. 186–194.

A new Hemipterous Insect from Boutan (East Indies), forming the Type of a New Genus (1849). Entom. Soc. Trans. i. 1850–51, pp. 1–3.

Notice of some Hemiptera from Boutan (Hon. East India Company) [1849]. Entom. Soc. Trans. i. 1850–51, pp. 4–11.

Note on the British Species belonging to the genus *Acanthosoma*, Curt. Entom. Soc. Trans. i. 1850–51, pp. 109–114.

Description of a new Hemipterous Insect forming the Type of a New Genus (*Atelides centrolineatus*). Annals and Mag. Nat. Hist. x. 1852, pp. 359 and 436.

Descriptions of some New Species of Hemipterous Insects belonging to the Tribe Scutata. Entom. Soc. Trans. ii. 1852–53, pp. 6–17.

Description of a New Species of the Genus *Dinidor*, belonging to the Hemiptera scutata. Entom. Soc. Trans. ii. 1852–53, pp. 18–19.

On the Feathers of *Dinornis robustus*, Owen, Ann. and Mag. Nat. Hist. xvi. 1865, pp. 66–69. Ann. Sci. Nat. iv. 1865 (Zool.), p. 292. Zool. Soc. Proc. 1865, pp. 265–268.

On the Occurrence of *Tinnunculus cenchris* in Britain. Ann. and Mag. Nat. Hist. ii. 1868, pp. 75–76.

Translator of C. T. von Siebold's work on a true Parthenogenesis in Moths and Bees. 8vo. London, 1857.

Translator of Prof. O. Heer's "Primæval World of Switzerland," in two vols. pp. 742; with 500 illustrations. (Longmans & Co., 1876).

Translator of "Facts and Arguments for Darwin," by Fritz Müller. 8vo. pp. 144. London, 1869. (J. Murray.)

Author of the articles Rodentia, Chiroptera, Insectivora, Hymenoptera, Neuroptera, Diptera, Aphaniptera, Rhynchota, Orthoptera, Thysanura, Myriopoda, Arachnida, in Cassell's Natural History. 1882.

Translator of vol. v. of Humboldt's Cosmos, 1858. 8vo. pp. 500. (Bohn's Scientific Series.)

Translated the foreign articles for the "Chemical Gazette" (1852–59), for the "Philosophical Magazine," for the "Reader," and for the "Annals and Magazine of Natural History" (1852–90).

Numerous reviews and articles in the "Westminster Review."

Translator of Buchner's "Man, Past and Present," and Nitzsch's "Pterylography." H. W.

SIR W. W. SMYTH, M.A., F.R.S.

It is with deep regret we record the death, from heart-disease, of Sir Warington W. Smyth, M.A., F.R.S., Foreign Secretary of the Geological Society of London; which occurred at his residence, 5, Inverness Terrace, on Thursday, the 19th June. An Obituary Notice will be given next month.